THE FUTURE OF TRANSPORTATION FUELS AND VEHICLES

HEARING

BEFORE THE

SUBCOMMITTEE ON ENVIRONMENT

OF THE

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CONTENTS

[1] The information can be found at: *https://docs.house.gov/meetings/if/if18/20180307/106958/hhrg-115-if18-20180307-sd090.pdf.*

THE FUTURE OF TRANSPORTATION FUELS AND VEHICLES

WEDNESDAY, MARCH 7, 2018

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENVIRONMENT,
COMMITTEE ON ENERGY AND COMMERCE
Washington, DC.

The subcommittee met, pursuant to call, at 10:15 a.m., in room 2322 Rayburn House Office Building, Hon. John Shimkus (chairman of the subcommittee) presiding.

Members present: Representatives Shimkus, McKinley, Barton, Harper, Johnson, Flores, Hudson, Walberg, Carter, Duncan, Walden (ex officio), Tonko, Peters, DeGette, McNerney, Dingell, and Pallone (ex officio).

Also present: Representative Loebsack.

Staff present: Mike Bloomquist, Deputy Staff Director; Daniel Butler, Staff Assistant; Kelly Collins, Staff Assistant; Adam Fromm, Director of Outreach and Coalitions; Ben Lieberman, Senior Counsel, Energy; Ryan Long, Deputy Staff Director; Mary Martin, Chief Counsel, Energy & Environment; Brandon Mooney, Deputy Chief Energy Counsel Advisor; Annelise Rickert, Counsel, Energy; Dan Schneider, Press Secretary; Jason Stanek, Senior Counsel, Energy; Hamlin Wade, Special Advisor, External Affairs; Everett Winnick, Director of Information Technology; Jeff Carroll, Minority Staff Director; Jean Fruci, Minority Energy and Environment Policy Advisor; Rick Kessler, Minority Senior Advisor and Staff Director, Energy and Environment; Alexander Ratner, Minority Policy Analyst; Andrew Souvall, Minority Director of Communications, Outreach and Member Services; and C.J. Young, Minority Press Secretary.

OPENING STATEMENT OF HON. JOHN SHIMKUS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ILLINOIS

Mr. SHIMKUS. The subcommittee will come to order and the chair recognizes himself for 5 minutes for an opening statement.

We have experienced very gradual and incremental change in the transportation fuels and vehicles over the last several decades, but there are signs that the pace of change will accelerate in the years ahead. In the not-too-distant future we may see cars in showrooms and fuel choices at retail stations that are noticeably different than what is available today. The purpose of this hearing is to provide an overview of the ongoing transition and learn more about what it all means for the American driving public.

I welcome our distinguished panel of experts. While nobody's crystal ball is perfect, the individuals and organizations represented here have done some of the best thinking about the future of personal transportation and I thank them for participating in this hearing.

Many factors are contributing to this evolving marketplace in transportation. One driver, no pun intended, is government policy. I should stress that this is not a hearing about the Renewable Fuels Standard, per se, or the Corporate Average Fuel Economy standards, or incentives for electrical vehicles. However, these and other federal policies are significant contributors to the changing fuels and vehicle marketplace and thus are an important part of the overall discussion.

For example, the Department of Energy is working with other agencies and national labs on its Co-Optima program to achieve breakthroughs in high octane fuels used in high compression engines. The program's goal is to cost effectively boost efficiency from the internal combustion engines and in so doing help reach a possible and possibly exceed the targets in both the RFS and CAFE. I look forward to hearing from Dr. Farrell on this and other research for which the National Renewable Energy Laboratory is a contributor.

But policy-driven change is only part of the picture. We are also seeing technological advances, whether it is getting EVs closer to the point where they make economic sense for more people, further progress on natural gas-powered vehicles that can take advantage of our domestic natural gas abundance, continued improvement in fuel cells, or other avenues of research. And for every alternative vehicle breakthrough, there are alternative fueling infrastructure challenges for which solutions are being developed.

I might add that today's discussion is not just about alternative fuels and vehicles. Research is also underway to improve the efficiency of the internal combustion engine and help it remain a cost-effective choice in the decades ahead. I mentioned Co-Optima and its integrated approach to high octane fuels and internal combustion engines that are optimized for them, but other research is also achieving breakthroughs in getting more efficiency out of the conventional technologies.

I should also note that advances in autonomous vehicles, including passage of the SELF DRIVE Act, have been the subject of a lot of good work by the Digital Commerce and Consumer Protection Subcommittee under Chairman Latta. Autonomous vehicles will also have an effect on the choice of fuels and vehicles that will be used in the future. It is all related, so we need to be mindful of everything going on in transportation research.

Of course, many factors are behind these transitions. Environmental considerations are certainly a factor, energy security is also a factor, but we can't lose sight of the most important thing and that is the impact on the consumer. We want to make owning, operating, and using a vehicle as affordable as possible for the American public and I hope this research helps in that regard.

In any event, change is happening in the transportation sector and I hope that today's hearing gives us all a better understanding of it. With that, my time, I am done with my opening statement.

Anyone who wants a minute or a half on either side, seeing none, I yield back my time and now recognize the ranking member of the subcommittee, Mr. Tonko, for 5 minutes.

[The prepared statement of Mr. Shimkus follows.]

PREPARED STATEMENT OF HON. JOHN SHIMKUS

We have experienced very gradual and incremental change in transportation fuels and vehicles over the last several decades, but there are signs that the pace of change will accelerate in the years ahead. In the not-too-distant future we may see cars in showrooms and fuel choices at retail stations that are noticeably different than what is available today. The purpose of this hearing is to provide an overview of this ongoing transition and learn more about what it all means for the American driving public.

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In any event, change is happening in the transportation sector, and I hope that today's hearing gives us all a better understanding of it. Thank you.

OPENING STATEMENT OF HON. PAUL TONKO, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. TONKO. Thank you, Mr. Chair. I want to thank you for holding today's very important hearing, addressing the future of our Nation's transportation fuels and vehicles. And thank you to all our witnesses for being here, Mr. Chair. I want to commend you on as-

sembling an expert panel that can inform members of ongoing trends and impending changes to our Nation's transportation sector.

It is beyond a doubt that our transportation sector is changing, that the mix of vehicles and fuels will be considerably different in 2050 than they are today. It will almost certainly be more diverse and cleaner. There are many benefits to reducing dependence on petroleum from improving national energy security to protecting consumers against the price volatility of the global oil market.

But the transportation sector is also key to addressing climate change. Vehicle miles traveled in the U.S. has continued to grow since the Great Recession and greenhouse gas emissions from transportation now exceed emissions from our power sector. It is clear that effective climate action needs to consider how to reduce transportation emissions.

Reducing emissions in the power sector has occurred much more quickly and can be done more cheaply, which is why electrification of transportation has become a priority for achieving emissions reduction goals. In recent years, improvements in electric vehicles have been impressive, including reductions in battery cost, increased range and greater changing infrastructure options and, increasingly, utilities are embracing the tremendous opportunity for increase on electricity demand. We can imagine an exciting future where vehicles offer the potential to balance loads on the grid as energy storage resources.

While impediments still exist for further EV deployment, we are trending in the right direction. Despite the excitement around electric vehicles we need to acknowledge that this transition is not going to happen overnight. The internal combustion engine will continue to make up a significant portion of our Nation's vehicle fleet in the coming decades.

We should also acknowledge that electrification will be more difficult to penetrate certain liquid fuel markets such as aviation, shipping, and potentially heavy duty vehicles, but we must make drastic reductions in greenhouse gas emissions immediately. Therefore, we need a multi-track approach backed by strong federal policies. This means continuing to make significant R&D investments and provide tax incentives for electric vehicles as well as supporting the growth of an advanced biofuels market.

Alternative fuels such as biodiesel and compressed natural gas can be cleaner options and displace dirtier fuels for heavy duty vehicles which is important to not only reduce greenhouse gas emissions, but also other hazardous air pollutants. And regardless of the fuel choice, we should ensure that vehicles are using these fuels as efficiently as possible.

Undoubtedly, CAFE standards played a role in development of technologies to improve fuel economy. Unfortunately, EPA Administrator Pruitt is reconsidering the greenhouse gas standards for model year 2022 through 2025 light duty vehicles and questioning whether the Agency's initial assumptions about technology development and costs from 2012 are still accurate and reasonable.

It is clear from the technical assessment as well as the robust and conclusive public record that these standards should be maintained. They are feasible, can be met at lower cost than originally

estimated, and can be achieved through a number of different technology pathways, many of which are already commercially available. In addition to saving consumers at the pump, EPA projects that the model year 2022–2025 standards will reduce emissions by more than 230 million metric tons by 2050 and nearly 540 million metric tons over the lifetime of model year 2022 to 2025 vehicles.

Similarly, we know the Administration is considering whether or not to support changes to the Renewable Fuel Standard. Like CAFÉ, this is an area that this subcommittee has examined and I would caution against unilateral action by the Administration which may not benefit consumers, put us on the path towards reducing transportation emissions, or increase domestic energy security. These federal policies along with tax incentives, R&D investments, and state policies are important pieces to shaping the future of transportation in our country.

Ultimately, other countries will continue to embrace electrification, low emissions liquid fuels, and fuel economy. They realize that their air quality depends on these developments and they recognize the threat of climate change as real and requires major commitments to reduce emissions from all sectors. The United States should continue to lead and innovate and ensure that our manufacturers, our automakers, and our refineries are able to deliver cutting edge vehicles and fuels for the United States and markets around the world.

With that Mr. Chair, I yield back.

Mr. SHIMKUS. The gentleman yields back his time. The Chair now recognizes the chairman of the full committee, Congressman Walden from Oregon, for 5 minutes.

OPENING STATEMENT OF HON. GREG WALDEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OREGON

Mr. WALDEN. Thank you, Mr. Chairman, appreciate it. Appreciate your leadership on this and so many other issues and I welcome our panelists here today.

As we explore the emerging trends of motor vehicles and the fuels that they use, across several federal agencies and national labs and throughout the private sector research as you all know is underway to make driving cleaner, safer, and more efficient. Regardless of whether this work is the result of government mandates or market forces, it nonetheless is going on and change is coming to the fuels and vehicles marketplace.

The purpose of this hearing is to get a better sense of this change and I welcome our witnesses as part of helping us better understand it. Today, we will hear about the environmental objectives, efficiency objectives, national security objectives, and other policies behind the evolving fuels and vehicles marketplace. But as we have this discussion, let us not forget the one thing that matters most and that is the interest of consumers.

Family car, it is the second most expensive purchase after a house and the average price for a new vehicle has risen to more than $36,000, up nearly $600 just from a year ago according to Kelley Blue Book. Yes, that is the average price and it is quite a burden for households as well as millions of small business owners

and farmers and ranchers who rely on their vehicles to make a living.

Naturally, the car buying public wants these sticker prices to go down rather than continue going up, same is true for fuels. The average household uses about a thousand gallons per year which makes fill-ups a very significant part of the family budget. Struggling families and businesses would like to see breakthroughs to bring down the cost of gasoline or alternative fuels. It is important to recognize that if new fuels and vehicles do not deliver consumer benefits then they likely won't deliver any environmental or other benefits either.

An auto dealer once told this subcommittee that even the most eco-friendly car won't do any good if it just sits in the showroom, and nobody I know has ever refuted that logic. Bottom line, the sources of alternative fuels in the marketplace relies heavily upon the ability to bring down the cost per mile traveled and the success of alternative vehicles relies on avoiding sticker shock.

So the good news is, the breakthroughs in fuels and vehicles can be done in a way that benefits consumers while also achieving environmental and other objectives. As someone who owns and drives a hybrid on both coasts, I hope we can work together to a future that is cleaner, safer, and more efficient, and yes, perhaps even less expensive transportation modes. I welcome this discussion on how we get there. This committee is committed to this effort and my friend from Illinois is putting a lot of time into the fuels issue along with others and so we look forward to your testimony today.

And with that, Mr. Chairman, unless anybody wants the remainder of my time, I would be happy to yield back so you can move along with the hearing.

[The prepared statement of Mr. Walden follows:]

PREPARED STATEMENT OF HON. GREG WALDEN

Today we are exploring the emerging trends in motor vehicles and the fuels they use. Across several Federal agencies and national labs and throughout the private sector, research is underway to make driving cleaner, safer, and more efficient. Regardless of whether this work is the result of government mandates or market forces, it is nonetheless going on and change is coming to the fuels and vehicles marketplace. The purpose of this hearing is to get a better sense of this change, and I welcome our witnesses who are a part of it.

Today, we will hear about the environmental objectives, efficiency objectives, national security objectives, and other policy reasons behind the evolving fuels and vehicles marketplace. But as we have this discussion, let us not forget the one thing that matters most, and that is the interests of consumers.

The family car is the second most expensive purchase after a house, and the average price for a new vehicle has risen to more than $36,000, up by nearly $600 from just a year ago, according to Kelley Blue Book. Yes, that is the average price, and it is quite a burden for households as well as the millions of small business owners and farmers and ranchers who rely on vehicles to make a living. Naturally, the car buying public wants to see sticker prices go down rather than continue going up.

The same is true for fuels. The average household uses about a thousand gallons per year which makes fill-ups a very significant part of the family budget. Struggling families and businesses would like to see breakthroughs that bring down the cost of gasoline or alternative fuels.

It's important to recognize that if new fuels and vehicles don't deliver consumer benefits, then they likely won't deliver any environmental or other benefits either. An auto dealer once told this subcommittee that even the most eco-friendly car won't do any good if it just sits in the showroom, and nobody I know has ever refuted that logic. Bottom line—the success of alternative fuels in the marketplace re-

lies heavily upon their ability to bring down the cost per mile traveled, and the success of alternative vehicles relies on avoiding sticker shock.

The good news is that the breakthroughs in fuels and vehicles can be done in a way that benefits consumers while also achieving environmental and other objectives. As someone who owns and drives a hybrid on both coasts, I hope we can look forward to a future of cleaner, safer, more efficient, and yes cheaper personal transportation, and I welcome this discussion on how we can get there.

Mr. SHIMKUS. The gentleman yields back his time. The chair now recognizes the ranking member of the full committee, Congressman Pallone from New Jersey, for 5 minutes.

OPENING STATEMENT OF HON. FRANK PALLONE, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW JERSEY

Mr. PALLONE. Thank you, Mr. Chairman. This morning we will examine the future of transportation fuels and vehicles, a future that will be shaped by federal policy.

While we have made significant progress in reducing emissions and improving fuel efficiency, I believe the Federal Government can and should do more. Last month, the EPA released the latest inventory of greenhouse gas emissions. For the first time, the transportation sector has edged out the electric power industry as the largest emitting sector. Transportation now accounts for 28.5 percent of our greenhouse gas emissions, with passenger vehicles contributing most of these emissions.

While the total emissions from transportation are lower for 2016 than for the peak year of 2005, the trend is still not good. Overall emissions from this sector increased between 2012 and 2016. History has shown that real progress in fuel efficiency and emission reduction from vehicles is a direct result of government policies.

CAFE standards and the emission control programs of the Clean Air Act have delivered great gains and the Renewable Fuel Standard program has provided us a reliable source of domestic fuel that has reduced both our dependence on petroleum and emissions from fuel combustion. Similarly, Federal tax incentives, research, procurement, and loan programs have helped spur the development and deployment of electric vehicles, battery technology, advanced biofuels, and other fuel and vehicle options.

But we must do more. Oil prices may be affordable and supplies may be abundant right now, but that situation can change. Experience demonstrates that the adjustments of rising prices is painful for everyone, from individual vehicle owners to auto manufacturers and all the businesses in their supply chains. A diverse fuel supply combined with enhanced fuel efficiency provides an important buffer against rising prices.

And if we do not do more to reduce transportation sector emissions, the effects of climate change are likely to accelerate and worsen. Moreover, vehicles are major purchases and reliable vehicles can remain on the road for up to 25 years, so it may take many years to see substantial changes in fuel consumption or emission reductions without aggressive federal policies.

And all of this has implications beyond our own borders. Two countries with the largest market potential, India and China, have signaled their intention to move beyond the internal combustion engine. Meanwhile, a number of European countries are reducing

or phasing out their use. U.S. auto manufacturers need to remain at the forefront of this industry and that will only happen if they maintain a diverse fleet of vehicles with improved fuel efficiency and reduce emissions. When U.S. auto succeeds, the country's economy also succeeds.

So let me say in closing that I am very concerned about the direction President Trump is taking on fuels and vehicle policies. Low fuel prices are already leading automakers and consumers to discount the importance of fuel economy as a consideration when making a vehicle purchase. The Trump administration's apparent intention to weaken the pending combined CAFÉ and greenhouse gas emission standards for light duty vehicles would take us in the wrong direction.

Meanwhile, the Administration's proposal to rescind EPA's glider truck rule which closes a gaping loophole in freight truck emission standards has rightly united both truck manufacturers and environmentalists in opposition. We need to spur innovation and reward it. We need the transportation sector to be cleaner and more fuel efficient. However, technologies to improve fuel efficiency, reduce emissions, and diversify fuel supplies will not appear on the market without the technology push provided by strong federal policy.

And rollbacks are, by definition, not a way to move forward. We can have cleaner, healthier air and vehicles that cost less to operate delivered by a globally competitive U.S. automobile industry if we stay the course.

And I don't think anyone else wants my time, so I will yield back, Mr. Chairman. Thank you.

Mr. SHIMKUS. The gentleman yields back his time. We now conclude with member opening statements. The Chair would like to remind members that pursuant to committee rules, all members' opening statements will be made part of the record.

We want to thank all of our witnesses for being here today and taking the time to testify before the subcommittee. Today's witnesses will have the opportunity to give an opening statement. Your full statements are already submitted for the record and your opening statement is to summarize that document and then followed by a round of questions from the members who will be remaining here.

Our witness panel for today's hearing will include Mr. John Maples, Senior Transportation Analyst, U.S. Energy Information Administration, thank you for being here; Dr. John Farrell, Laboratory Program Manager, Vehicles Technologies, National Renewable Energy Laboratory; Dr. Joshua Linn, Senior Fellow, Resources for the Future; Dr. Jeremy Martin, Senior Scientist and Fuels Lead, Clean Vehicles Program, Union of Concerned Scientists; and Mr. John Eichberger, Executive Director of the Fuels Institute.

We appreciate you all being here today. We will now begin with Mr. Maples, and you are recognized for 5 minutes. Thanks for being here.

STATEMENTS OF JOHN MAPLES, SENIOR TRANSPORTATION ANALYST, U.S. ENERGY INFORMATION ADMINISTRATION; JOHN FARRELL, LABORATORY PROGRAM MANAGER, VEHICLES TECHNOLOGIES, NATIONAL RENEWABLE ENERGY LABORATORY; JOSHUA LINN, SENIOR FELLOW, RESOURCES FOR THE FUTURE; JEREMY MARTIN, SENIOR SCIENTIST AND FUELS LEAD, CLEAN VEHICLES PROGRAM, UNION OF CONCERNED SCIENTISTS; AND JOHN EICHBERGER, EXECUTIVE DIRECTOR, FUELS INSTITUTE

STATEMENT OF JOHN MAPLES

Mr. MAPLES. Thank you. Chairman Shimkus, Ranking Member Tonko, and members of the committee, I appreciate the opportunity to appear before you today. The Energy Information Administration is the statistical and analytical agency within the Department of Energy. By law, EIA's data, analyses, and projections are independent, so my comments should not be construed as representing those of Department of Energy or any other federal agency.

My statement focuses on the Reference case of the EIA Annual Energy Outlook 2018 which presents projections for the U.S. energy system through 2050. The AEO 2018 Reference case is a business-as-usual, trend estimate using known technology and technological and demographic trends and with the assumption that current laws and regulations remain unchanged throughout the projection period. My oral statement will focus on light duty vehicles, passenger cars, and light trucks, which accounted for 55 percent of total transportation energy use in 2017, the base year for the AEO 2018.

The Reference case includes the CAFÉ and greenhouse gas emission standards as issued by NHTSA and EPA for multi-years' 2017 through 2025, as well as the California Zero Emission Vehicle program adopted by nine additional states— to see that map, see Figure 1 in my written statement—and existing tax credits for alternative and advanced vehicles and fuels.

Total transportation energy consumption peaked in 2017 in the Reference case at 13.1 million barrels per day. With CAFE standards and advanced technologies, average new light duty vehicle economy rises from 33.4 mpg to 48.6 mpg by 2050. Total vehicle miles of travel grow 18 percent between 2017 and 2050, yet energy consumption decreases by 30 percent by 2042.

Starting with vehicle sales, sales of conventional gasoline vehicles continue to dominate, but the share declines from 87 percent today to 71 percent in 2050. Electrified vehicles including battery electric, plug-in hybrid electric, and full hybrid electric grow strongly, rising from 4 percent of new sales in 2017 to 19 percent in 2050. Battery-only electrics grow to 12 percent due to policies such as California's ZEV regulation, declining battery cost, and longer-ranged models.

Hybrid electric sales rise to 5 percent from 3 percent, plug-in hybrid electrics from 1 percent to 2 percent, E85 flex-fuel vehicles reach 7 percent by 2050, sales of diesel, natural gas, propane, and fuel cell vehicles are all at 2 percent or less in 2050.

Now for fuel shares, while petroleum products remain dominant for light-duty vehicles to 2050, see Figure 5, gasoline with ethanol

falls from 99.5 percent to 91 percent by 2050. The E85 share rises from 0.1 percent to 1.5 percent, electricity usage grows to 4.7 percent, diesel to 2 percent, and natural gas is negligible.

The key areas of uncertainty in the Reference case are fuel prices, the digital economy, consumer acceptance, and potential changes in policies. Higher or lower fuel prices can change the relative attractiveness of all vehicle types. In the High Oil Price case, the sales shares of conventional gasoline vehicles declines to about 62 percent in 2050 compared to 71 percent in the Reference case. In the Low Price case, the shares go up a couple of percent. In all cases, High and Low Oil Prices and the Reference case, fuel consumption decreases.

On-demand ride-hailing is already affecting how consumers utilize personal vehicles and mass transit. At this point, the potential energy impact of autonomous vehicles is unclear and open to wide variation. Customer acceptance affects the future market success of vehicle types and alternative fuels. For example, cost and performance, alternative fuel prices, and the availability of refueling infrastructure are all going to have an impact.

Finally, the future regulatory environment is uncertain. The EIA is currently working on Issues in Focus articles associated with the AEO2018 that will cover potential impacts on future energy demand. This analysis will likely be released in late spring. This concludes my statement and I will be happy to answer questions from the committee.

[The prepared statement of Mr. Maples follows:]

STATEMENT OF JOHN MAPLES

SENIOR TRANSPORTATION ANALYST

ENERGY INFORMATION ADMINISTRATION

U.S. DEPARTMENT OF ENERGY

before the

SUBCOMMITTEE ON ENERGY AND POWER

COMMITTEE ON ENERGY AND COMMERCE

U. S. HOUSE OF REPRESENTATIVES

March 7, 2018

Mr. Chairman and Members of the Subcommittee, I appreciate the opportunity to appear before you today to address the outlook for light-duty vehicles and the fuels used in those vehicles.

The Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy. EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment. EIA is the Nation's premier source of energy information and, by law, its data, analyses, and forecasts are independent of approval by any other officer or employee of the United States Government. The views expressed herein should therefore not be construed as representing those of the Department of Energy or other federal agencies.

Petroleum dominates energy use in transportation

The transportation sector and the use of petroleum fuels are tightly linked. In 2017, 38% of total U.S. energy and 72% of total U.S. petroleum and other liquids were consumed in the transportation sector, while petroleum products provided about 97% of total transportation energy. Light-duty vehicles (LDVs), including both passenger cars and light-duty trucks, accounted for 55% of total transportation energy use in 2017 (Table 1). Heavy-duty vehicles (HDVs), including freight and commercial-light trucks and buses, used 24% of transportation energy, followed by aircraft, marine, pipeline, and rail with shares of 9%, 5%, 2%, and 2% in total transportation energy use, respectively.

Table 1. Breakout of 2017 energy consumption by mode in the transportation sector

	LDV	HDV	Aircraft	Marine	Pipeline	Rail	Other
Percent of consumption by mode	55%	24%	9%	5%	2%	2%	2%

*The percentages may not sum to 100% due to rounding
Source: EIA *Annual Energy Outlook 2018*, Reference case

LDVs are almost entirely fueled by petroleum products, with motor gasoline, which includes blended ethanol, accounting for over 99% (7.2 million barrels per day crude oil equivalent (million b/d)) of energy use. On a volumetric basis, about 10% of motor gasoline is blended ethanol. The remaining 1% includes minor amounts of diesel, gaseous fuels, electricity, and E85, a blend of up to 85% ethanol with motor gasoline. For HDVs, petroleum and other liquids are central to meeting energy needs, with diesel, including biodiesel blends, accounting for 81% of consumption (2.6 million b/d) and motor gasoline, including ethanol blends, accounting for 18% (0.6 million b/d). About 6% of diesel fuel is blended biodiesel. The remaining 1% is almost entirely compressed or liquefied natural gas. Of the other transportation modes, aircraft (1.1 million b/d) and marine (0.6 million b/d) are also almost entirely dependent on petroleum products while rail energy consumption is 96% diesel (0.3 million b/d) and 4% electricity.

Table 2. Consumption of liquid fuels by mode in 2017 (million b/d)

	LDV	HDV	Air	Marine	Rail
Motor gasoline	7.2	0.6		0.1	
Diesel	0.0	2.6		0.2	0.3
Jet fuel			1.1		
Residual fuel oil				0.3	
Total	7.2	3.2	1.1	0.6	0.3

Source: EIA *Annual Energy Outlook 2018*, Reference case

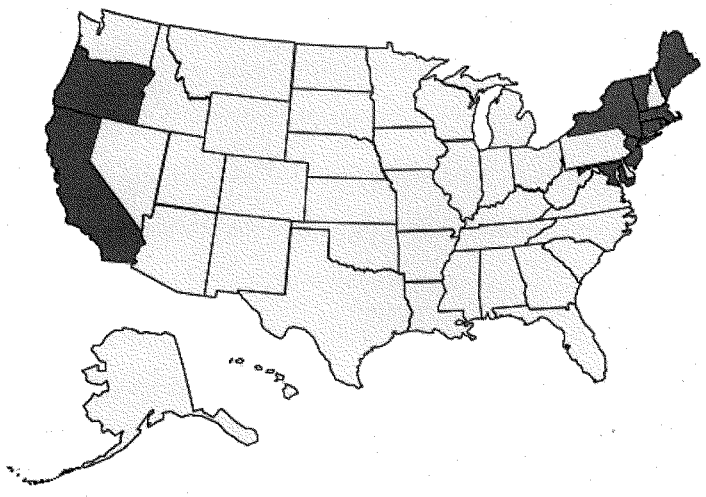
The *Annual Energy Outlook 2018*

EIA recently released the *Annual Energy Outlook 2018* (*AEO2018*), which presents projections for the U.S. energy system through 2050. The *AEO2018* Reference case is a business-as-usual trend estimate, using known technology and technological and demographic trends, and is prepared under the assumption that current laws and regulations remain unchanged throughout the projection period. The large share of U.S. energy and petroleum use by LDVs has made them a focal point for legislation, regulation, and tax policies to both improve fuel economy and promote the sale of alternatively-fueled vehicles and alternative fuels. In recent years, regulations improving the fuel efficiency of HDVs have also become prominent. Higher fuel efficiency standards reduce both petroleum and energy consumption, while alternatively-fueled vehicles and fuels displace the use of petroleum without necessarily reducing overall energy use.

The *AEO2018* Reference case includes the jointly issued Corporate Average Fuel Economy (CAFE) and LDV greenhouse gas emissions standards for model years (MY) 2017 to 2025 promulgated by the National Highway Traffic Safety Administration

(NHTSA) and the Environmental Protection Agency (EPA). This includes the final joint rulemaking for MY 2017 to 2021 and the standards in place for MY 2022 to 2025, which will undergo a midterm evaluation before finalization in the near future. In addition, the Reference case incorporates other provisions impacting the transportation sector, such as California's Zero Emission Vehicle (ZEV) program adopted by 9 additional states – Connecticut, Massachusetts, Maryland, Maine, New Jersey, New York, Oregon, Rhode Island, Vermont (Figure 1); NHTSA and EPA's jointly issued Phase I and Phase II fuel consumption and greenhouse gas emission standards for on-road heavy duty vehicles through MY 2027; existing tax credits for alternative/advanced vehicles and fuels; and ship emission regulations set under the International Convention for the Prevention of Pollution from Ships (MARPOL). Standards are held constant at the level of the last regulated year throughout the remainder of the projection.

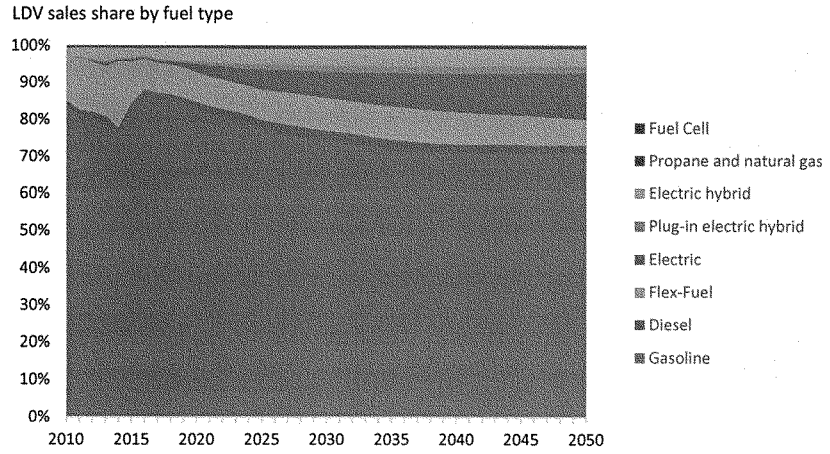
Figure 1. States with mandates for zero emission vehicles



Transportation energy consumption peaked in 2017 in the Reference case at 13.1 million b/d and declines until 2037, reaching a low of 11.2 million b/d before rising again through the end of the projection to 12.0 million b/d by 2050. Rising fuel efficiency outweighs the increases in total travel and freight movement in the first half of the projection, before reversing in the second half of the projection after the current CAFE standards are no longer in effect to increase fuel efficiency in the Reference case. LDVs see the largest change in energy consumption in transportation, because of rising fuel efficiency of all vehicle fuel types as well as growing sales of electrified and non-gasoline fueled vehicles.

While sales of conventional gasoline LDVs remain predominate throughout the *AEO2018* Reference case, the sales share declines from 87% in 2017 to 71% in 2050 (Figure 2).

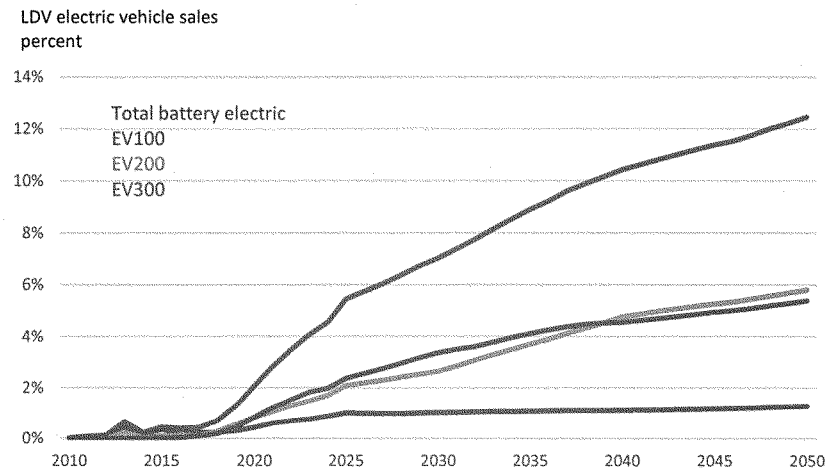
Figure 2. Light-duty vehicle powertrain market share



Source: EIA *Annual Energy Outlook 2018*, Reference case

Electrified vehicles, including battery electric (BEV), plug-in hybrid electric (PHEV), and full hybrid electric (HEV), grow strongly across the projection, rising from 4% of new LDV sales in 2017 to 19% by 2050. This sales increase is led by BEVs, which grow from less than 1% in 2017 to 12% by 2050 because of state policies such as California's ZEV regulation, declining battery costs, and the availability of longer-ranged 200- and 300-mile BEV models (Figure 3). Between 2017 and 2050, HEV sales grow from 3% of new sales to 5% while PHEVs grow from 1% to 2%, respectively.

Figure 3. Percent of electric light-duty vehicle sales out of total light-duty vehicle sales by range



Source: EIA *Annual Energy Outlook 2018*, Reference case

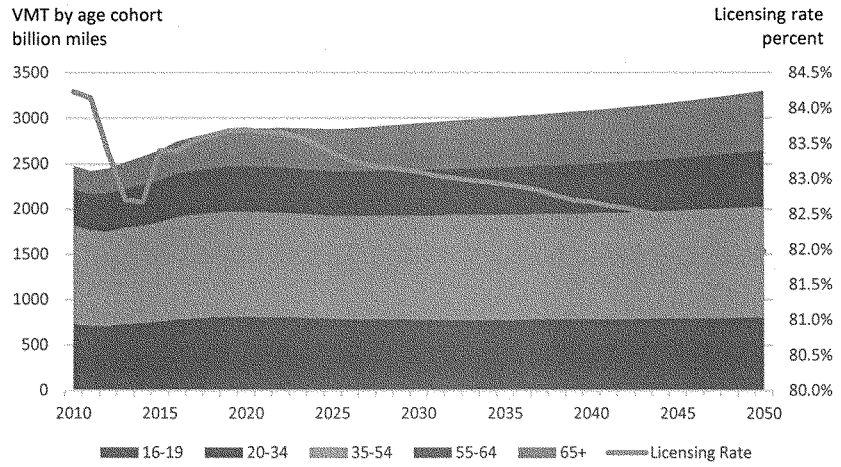
Flex-fuel vehicles (FFVs), which can use E85 blends, are projected to be 7% of LDV sales by 2050. Manufacturers selling FFVs currently receive incentives in the form of fuel economy credits earned for CAFE compliance through MY 2019. FFVs also play a

critical role in accommodating the RFS mandate for increased use of biofuels. Diesel vehicles account for 2% and natural gas, propane and fuel cell vehicles account for about 1% of new vehicle sales in 2050 (Figure 2).

In addition to the changing vehicle fuel mix, the decline in LDV energy and motor gasoline consumption in the *AEO2018* Reference case is due to rising new vehicle fuel economy. Average new LDV fuel economy rises from 33.4 miles per gallon (mpg) in 2017 to 46.9 mpg by 2025 and 48.6 mpg by 2050 because of CAFE standards and the use of advanced fuel-efficient technologies. Significant adoption of these technologies increases the fuel economy of all vehicle fuel types, including conventional gasoline, where, for example, about 20% of new conventional gasoline vehicles are equipped with micro-hybrid technology, by 2025. Micro-hybrid technologies turn the engine off when coming to a complete stop which reduces fuel consumption.

The changing mix of LDV sales is reflected over time in the composition of the LDV fleet. By 2050, about 25% of total LDVs are unconventional vehicles, non-gasoline and non-diesel vehicles, which contribute to higher efficiency or provide a capability for increased use of fuels other than petroleum. Growth in the number of drivers and vehicle miles per driver results in a projected growth of 18% in total LDV vehicle miles of travel between 2017 and 2050 in the *AEO2018* Reference case (Figure 4.)

Figure 4. Total light-duty vehicle miles traveled by age cohort and licensing rate



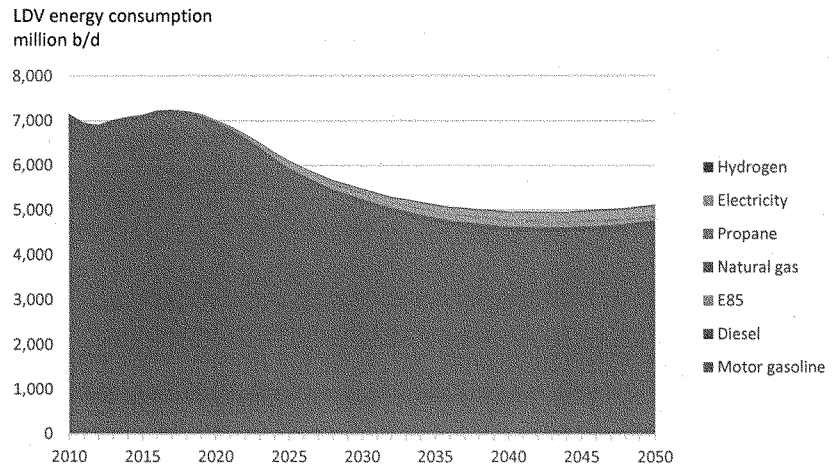
Source: EIA *Annual Energy Outlook 2018*, Reference case

However, due to rising fuel economy, overall LDV energy consumption is projected to decrease by 30%, or 4.5 quadrillion Btu, between 2017 and 2042 despite rising travel demand. After 2042, both travel demand and LDV energy consumption increase as the improvements in fuel economy level off. Projected LDV petroleum use in 2050 is about 4.8 million b/d, compared to 7.2 million b/d in 2017, reflecting both changes in the fuel mix and improved fuel economy.

Petroleum products remain the dominant LDV fuel, with the motor gasoline (including ethanol) share falling to 91% (from 99.5% in 2017) but diesel rising to 2% (from 0.4%) by 2050. E85, which contains up to 85% ethanol, plays a growing role and are projected

to provide 1.5% energy used by LDVs by 2050, up from less than 0.1% in 2017. Electricity usage grows to 4.7% while natural gas accounts for less than 0.1% (Figure 5).

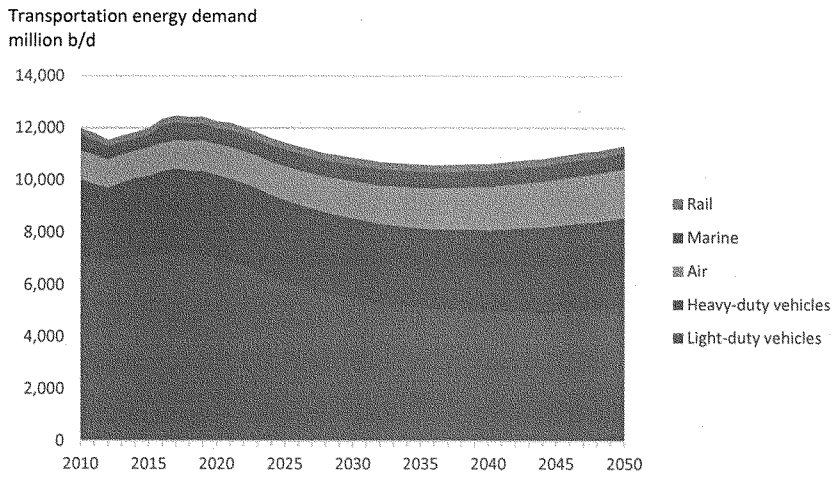
Figure 5. Light-duty vehicle energy use by fuel



Source: EIA *Annual Energy Outlook 2018*, Reference case

While total energy consumption is expected to decrease in the LDV sector other transport sectors are projected to grow during this period. Air travel demand has been growing over the last 20 years and is expected to continue growing throughout the projection. Between 1998 and 2017 revenue passenger miles and revenue ton miles have increased by 46% and 39% respectively. Over the projection period energy consumption from air travel increases by 70% while energy use by HDVs increases by 10% (Figure 6).

Figure 6. Transportation energy demand by mode



Source: EIA *Annual Energy Outlook 2018*, Reference case

Uncertainty in the *AEO2018* projections for the LDV vehicle mix and fuel use

The *AEO2018* Reference case projections for LDVs and their fuel use are inherently uncertain. The four key areas of uncertainty are: fuel prices, growth in the digital economy, consumer acceptance, and potential changes in policies.

First, all vehicle types face uncertainty regarding future fuel prices. Higher or lower fuel prices can change the relative attractiveness of all vehicle types, either making more fuel-efficient vehicles more attractive to consumers in a high oil price case or less attractive in a low oil price case. For example, in the *AEO2018* High Oil Price case, the conventional gasoline vehicle sales share declines to about 62% in 2050 compared to 71% in the Reference case, while in the Low Oil Price case, conventional gasoline make up 73% of LDV sales. Higher or lower fuel prices also affect projected vehicle efficiencies and

growth in travel, which also affect the fuel mix and the level of fuel use. In the *AEO2018* Low Oil Price case, overall LDV fuel consumption decreases by 9% between 2017 and 2050, while LDV fuel consumption decreases by 47% in the *AEO2018* High Oil Price case, compared to 30% in the *AEO2018* Reference case. LDV petroleum use in 2050 is 6.6 million b/d and 3.9 million b/d in the *AEO2018* Low and High Oil Price cases, respectively, compared to 4.8 in the *AEO2018* Reference case.

Second, the digital economy is changing transportation. On-demand ride-hailing is affecting how consumers utilize personal vehicles and mass transit. Moving forward, autonomous vehicles are expected to affect the transportation system in numerous ways. Highly automated vehicles are expected to change the perceived cost of travel, affect the use of on-demand ride-hailing services and mass transit, travel and driving patterns, the design of vehicles, the type of fuel used, and vehicle ownership. Although ride-hailing and autonomous vehicles are included in our long-run projections, there are great uncertainties over the scope of the on-demand ride-hailing and autonomous vehicles, as well as the benefits and costs of autonomous technology. Further, there remain several key inhibiting obstacles for autonomous vehicles. All of these factors combine to make the potential energy impact of autonomous vehicles unclear and open to wide variation.

Third, consumer acceptance is also a critical area of uncertainty regarding future market success of unconventional vehicles and alternative fuels. Vehicle attributes, such as cost and performance, as well as alternative fuel prices and availability, will play key roles in

the future success of alternative-fueled vehicles. Further, refueling infrastructure availability is essential to consumer acceptance.

Finally, the future regulatory environment is also uncertain. The possible effect of changes in fuel economy standards are an important uncertainty affecting projections of the LDV vehicle mix and fuel use. CAFE and greenhouse gas emission standards for LDVs are currently set in final rule form only through MY 2022. While the *AEO2018* assumes that standards are raised through MY 2025, changes in fuel efficiency requirements could impact the mix of LDV sales and projected fuel use by LDVs. State policy regarding ZEVs also relates to LDV fuel economy and sales mix and EIA includes regulatory credit requirements for ZEVs in the ten states mentioned earlier in the statement.

To further examine some of these uncertainties in the transportation sector, EIA is currently working on Issues in Focus articles associated with AEO2018 that will cover potential impacts on future transportation energy demand. These analyses, which will likely be released in late spring, will focus on framing some of the uncertainties discussed today with alternative cases, such as those that examine changes in fuel economy standards and differing levels of autonomous vehicle adoption.

This concludes my statement, Mr. Chairman, and I will be happy to answer any questions you and the other Members may have.

EIA: Summary of John Maples Statement

The statement focuses on the reference case of the EIA Annual Energy Outlook 2018 which presents projections for the U.S. energy system through 2050. The *AEO2018* Reference case is a ***business-as-usual, trend estimate***, using known technology and technological and demographic trends, and with the assumption that current laws and regulations remain unchanged throughout the projection period.

The focus is on light duty vehicles – passenger cars and light-duty trucks - which accounted for 55% of total transportation energy use in 2017, the base year for AEO 2018. Total transportation energy consumption peaked in 2017 in the Reference case at 13.1 million b/d. With CAFE standards and advanced technologies, average new light duty vehicle fuel economy rises from 33.4 mpg to 48.6 mpg by 2050. Total vehicle miles of travel grow 18% between 2017 and 2050, yet energy consumption decreases by 30% by 2042.

Sales of conventional gasoline vehicles continue to dominate, but the share declines from 87% to 71% in 2050. Electrified vehicles, including battery electric (BEV), plug-in hybrid electric (PHEV), and full hybrid electric (HEV), grow strongly rising from 4% of new sales in 2017 to 19% in 2050. Battery-only electrics grow to 12% due to policies such as California's ZEV regulation, declining battery costs and longer-ranged models. Hybrid electric sales rise to 5 from 3%, plug in hybrid electric vehicles from 1% to 2%. E85 flex-fuel vehicles reach 7% by 2050; sales of diesel, natural gas, propane and fuel cell vehicles are all at 2% or less in 2050.

While petroleum products remain dominant for light duty vehicles to 2050 gasoline (with ethanol) falls from 99.5% to 91% by 2050. The E85 share rises from .1% to 1.5%. Electricity usage grows to 4.7%, diesel to 2%, natural gas is negligible.

The key areas of uncertainty in the Reference case are: fuel prices, growth in the digital economy, consumer acceptance, and potential changes in policies. Higher or lower fuel prices can change the relative attractiveness of all vehicle types. In the High Oil Price case, the sales share of conventional gasoline vehicles declines to about 62% in 2050 compared to 71% in the Reference case. In the Low Oil Price case, the share goes up a couple of percent.

On-demand ride-hailing is already affecting how consumers utilize personal vehicles and mass transit. Autonomous vehicles are expected to affect the transportation system in numerous ways. At this point, the potential energy impact of autonomous vehicles is unclear and open to wide variation.

Consumer acceptance affects future market success of vehicle types and alternative fuels - cost and performance, alternative fuel prices and availability, and refueling infrastructure availability. Finally, the future regulatory environment is also uncertain. EIA is currently working on Issues in Focus articles associated with AEO2018 that will cover potential impacts on future transportation energy demand, this analysis will likely be released in late spring.

Mr. SHIMKUS. Thank you very much. The gentleman yields back his time. The chair now recognizes Dr. John Farrell. You are recognized for 5 minutes. Thanks for being here.

STATEMENT OF JOHN FARRELL

Mr. FARRELL. Chairman Shimkus, Ranking Member Tonko, members of the subcommittee, thank you for the opportunity to address this hearing on the future of transportation. My name is John Farrell and I am the Laboratory Program Manager for Vehicles Technologies at the Department of Energy's National Renewable Energy Laboratory in Golden, Colorado. I manage DOE's Co-Optimization of Fuels & Engines, or Co-Optima Initiative, and a range of other transportation R&D work at NREL. Prior to joining NREL, I worked for 15 years at ExxonMobil's Corporate Research Laboratory where I oversaw R&D focus on advanced fuels and vehicles in collaboration with several leading car and truck companies.

Mobility is foundational to our way of life. Today in the United States we are on the cusp of a wave of innovation that will dramatically transform our transportation sector. Innovations in vehicles, fuels, and infrastructure are being driven to a large extent by research led by DOE, NREL, other national laboratories, and our key industry partners. Our work holds the promise of providing mobility that is more convenient, affordable, and energy efficient, while at the same time boosting our Nation's economy and our overall global competitiveness.

It is often noted that transportation is poised to undergo simultaneous evolutions due to the advent of connected, autonomous, shared, and electrification technologies. While the impact of these advanced mobility technologies will indeed be wide-ranging, it is also true that vehicles with conventional internal combustion engines will remain an important component of our transportation system for decades to come.

That is why DOE and NREL are spearheading the Co-Optima Initiative which, in collaboration with eight other national labs and 13 universities, is conducting research that will help fuel producers and engine makers put the most efficient, high performance cars and trucks on the road. Much of our work to date has focused on identifying the benefits of fuel properties such as octane and enabling high efficiency gasoline engines and the role that blend stocks such as ethanol could play in providing these properties near term.

Co-Optima gives us the opportunity to save American consumers and commercial truck operators up to $35 billion a year in fuel expenses while maximizing vehicle performance and efficiency, intelligently leveraging domestic resources such as non-food biomass, expanding job opportunities, and enhancing energy security. Research is also on the way on transportation connectivity and automation. By automating driving and other functions and enabling vehicles to communicate with each other and with the transportation network, this complex arena of new technologies foretells a future with reduced congestion and smoother traffic flows, saving us all a lot of time and money.

The Sustainable Mobility program at NREL is working to support and complement DOE's SMART Mobility initiative. A major

goal of this effort is to fully integrate electrified vehicles with the electric grid to ensure that when large numbers of electric vehicles enter the marketplace they will work smoothly with renewable energy sources, with buildings, and with the entire expanse of our transportation infrastructure.

Fuel cell vehicles are now commercially available and have a range in refueling times comparable to conventional vehicles and achieve no tailpipe emissions. Our R&D has played a critical role in the advancement of technology for fuel cell vehicles and related hydrogen infrastructure needs. For electric vehicle charging infrastructure, NREL and the DOE labs are working on technology that will help establish a national network of extreme fast-charging stations capable of recharging batteries in a fraction of the time currently required, and we are exploring wireless in-road charging options for the longer term.

Commercial trucking also stands to benefit greatly from the new technology. DOE and NREL are exploring fuel cell and battery strategies for truck electrification that could substantially reduce fuel expenses, lower maintenance costs, and reduce emissions. The lab has forged strong partnerships with industry leaders and numerous fleet operators. With fuel costs amounting to 40 percent of trucking expenses, greater fuel efficiency could save commercial fleet operators and you, as consumers, hundreds of millions of dollars annually.

It is increasingly clear that we will need huge amounts of data and super computers to analyze the model at all if we are to coordinate and optimize the myriad of new technologies that will comprise tomorrow's interconnected transportation network. NREL's portfolio of databases each maintain and provide access to a wealth of invaluable, real-world, on-road transportation and energy systems data. These tools are already making a substantial contribution to the numerous R&D activities I have described.

As you can see, mobility R&D is critical to our Nation's transportation future. And as we contemplate the resource portfolio needed to get us there, we can be assured that the global race for new technology solutions will only intensify. Maintaining our leadership and innovation is as important now as ever. Thank you.

[The prepared statement of Mr. Farrell follows:]

Prepared Statement of Dr. John Farrell
Laboratory Program Manager, Vehicle Technologies
National Renewable Energy Laboratory
For the House Energy & Commerce Committee
Subcommittee on Environment

March 7, 2018

A Comprehensive Approach to Transforming Transportation

Chairman Shimkus, Ranking Member Tonko, members of the Subcommittee, thank you for this opportunity to address this hearing on the future of transportation. My name is John Farrell, and I'm the Laboratory Program Manager for Vehicle Technologies at the U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL) in Golden, Colorado. For the last five years I've managed NREL's research and development (R&D) efforts that fall within DOE's Office of Energy Efficiency and Renewable Energy (EERE) Vehicle Technologies Office portfolio. This work includes innovation in fuels, engines, electric vehicle technologies, fueling and charging infrastructure, and systems to support integration of vehicles, the grid, and the built environment. In addition, I act as Project Technical Lead for DOE's multi-lab, multi-office Co-Optimization of Fuels & Engines (Co-Optima) initiative.

Prior to joining NREL, I worked for 15 years in ExxonMobil's Corporate Research Laboratory. There, I applied my expertise to R&D programs, including collaborations between ExxonMobil and Ford, Caterpillar, Toyota, and other manufacturers. I have served on the advisory board for the Princeton Combustion Energy Frontier Research Center and have advised the U.S. Department of Defense on research initiatives. I hold a bachelor's degree in chemistry from Purdue University and a PhD in physical chemistry from the University of Colorado, and I completed my post-doctoral studies at Sandia National Laboratories.

Our nation's transportation system today is a marvel of utility and complexity. It might be tempting to assume that advances in vehicle technologies, especially engines, have run their course. Nothing could be further from the truth. In fact, we see before us a wave of innovation that will dramatically reshape the concept of transportation as we know it today—innovation that is being spurred on by DOE, NREL, other national laboratories, universities, and a wide range of industry partners.

The work led by DOE, NREL, and the other national labs holds the promise to revolutionize American energy productivity. This translates into mobility that is more convenient, affordable, and energy efficient, which will deliver major benefits including enhanced domestic economic prosperity and a stronger position in relation to global competitors.

Last year alone, vehicles moved people more than 3 trillion vehicle-miles and transported some 11 billion tons of freight—goods worth more than $32 billion each day to the American economy. Those vehicles used 70% of the record 19.69 million barrels of petroleum consumed per day. For the typical American, transportation is the second greatest expense after housing, and the average city commuter wastes approximately 42 unproductive hours per year stuck in traffic.

A full spectrum of transportation R&D is underway to improve the efficiency, performance, and affordability of transportation options for consumers and businesses. Electric-drive vehicles (EDVs), including fully electric, hybrid, plug-in hybrid, and fuel cell vehicles, are a substantial focus for NREL, as are autonomous and connected vehicle innovations. At the same time, we're making huge strides in improving the more conventional fuel and propulsion technologies that will continue to play an important role in transportation solutions for decades to come. Biofuel and natural gas-fueled vehicles provide opportunities for greater energy security and economic growth through the use of domestic resources.

In each instance, the world-class expertise and scientific capabilities of the national laboratories are being leveraged for the early-stage research that's pushing innovation forward. As valuable breakthroughs emerge, they provide government and industry decision makers with the scientific foundation needed to objectively weigh options, so consumers and businesses can reap the benefits.

Optimizing Efficiency of Vehicles with Internal Combustion Engines

Given the time it can take to develop and bring new automotive technologies to the marketplace, the high-energy density offered by liquid fuels, and the extensive network of gasoline distribution and fueling infrastructure, vehicles with internal combustion engines will continue to comprise a significant portion of the nation's vehicle fleet for at least the next few decades. DOE and NREL are spearheading the Co-Optima initiative to simultaneously improve fuel and engine performance with enhancements that build on the vehicle technologies and infrastructure already in use across the nation.

More efficient and sophisticated engines are already being introduced to the market, but their performance is limited by current fuels. Co-Optima researchers are thinking about fuels in a new way, as design variables to optimize these engines, with an eye toward revolutionizing the entire on-road fleet, from light-duty passenger cars to heavy-duty freight trucks.

DOE, NREL, and partners from eight other national labs and 13 universities are providing industry with the scientific underpinnings needed to accelerate introduction of high-performance fuels and engines. Much of the Co-Optima research is focused on

components known as blendstocks that can be added to fuel and used in smaller but more powerful and efficient spark-ignition engines. Blendstocks can be produced from a wide spectrum of domestic resources, including non-food, domestic biomass such as forestry and agricultural residues, energy crops, algae, and other renewable and surplus waste resources. Leveraging domestic biomass resources can support rural economies, create much-needed new jobs in farm country, and enhance energy security while keeping energy dollars in America.

Recent Co-Optima findings pinpoint five options of chemical families that show the greatest promise for creating blendstocks capable of meeting these goals with advanced versions of the engines most of us use today. In addition to researchers' work in the lab, Co-Optima analysts are developing a comprehensive understanding of the cost, infrastructure and vehicle compatibility, and air quality implications of producing these blendstocks.

While the research team has made considerable progress towards its goals, significant work is still needed to maximize passenger vehicle fuel economy and performance. Current Co-Optima scientific experimentation is focused on identifying how engine parameters and fuel properties will work in tandem to improve light-duty gasoline-fueled spark ignition engine efficiency and emissions in the near term. Research is also examining strategies to deliver similar benefits through optimization of fuels and engines for heavy- and medium-duty trucks. In addition, the team is exploring development of revolutionary engine technologies for a longer-term, higher-impact series of solutions.

Ultimately, this early-stage R&D and analysis will provide fuel producers and engine makers with greater flexibility in delivering fuels and components needed to put the most efficient and high-performance cars and trucks on the road. Combined with other R&D already underway, Co-Optima strategies present the opportunity to save American consumers and commercial truck operators as much as $35 billion dollars per year at the pump, while maximizing vehicle performance and efficiency, leveraging domestic fuel resources, boosting jobs, and enhancing energy security.

Taking a Full-Systems Approach with Sustainable Mobility

Today's transportation system is poised for dramatic transformation at the nexus of connectivity and automation. Rapid proliferation of automated vehicle technologies and connected, on-demand mobility services, coupled with lightning-speed advances in communications and sensor technologies, are revolutionizing the way people think about moving individuals and goods from Point A to Point B.

Optimized systems solutions can reduce congestion, smooth traffic flows, maximize occupancy for fewer "empty" miles, recommend quicker routes, and allow vehicle right-

sizing. Identifying novel mobility solutions requires that we view mobility as a network of services, travelers, and environments—rather than simply vehicles and roads.

NREL's Sustainable Mobility research supports DOE's Systems and Modeling for Accelerated Research in Transportation (or SMART) Mobility initiative in integrating research focused on fully-electric vehicles (EVs), the electric grid, renewable energy sources, buildings, and transportation infrastructure to move energy savings and connectivity to the next level.

Communication between vehicles and infrastructure gives drivers the ability to make better driving decisions, and automated controls can eliminate stop-and-start patterns by accelerating and slowing vehicles in concert with traffic light timing. Communication between cars not only improves safety, but also traffic flow by allowing automated control of speeds and distances between vehicles.

One important area of research is assessing the potential impacts of connected and automated vehicle technologies on fuel use and efficiency, vehicle miles traveled, and consumer costs. NREL analyses point to a wide range of possible energy scenarios, ranging from a tripling of light-duty vehicle consumption (due primarily to convenience encouraging a higher volume of travel), to a 40% decrease from today's levels of energy consumption (thanks in large part to technology improvements).

An element critical to the success of these transformational transportation solutions is EVs' potential to help balance loads and improve the resiliency of our nation's electricity infrastructure. Renewable energy sources are naturally variable, requiring energy storage or a hybrid system to accommodate daily and seasonal changes. Vehicle-to-grid technology makes it possible to store surplus electricity generated from intermittent renewable solar and wind sources in EV batteries during non-peak periods and feed power back to the grid when needed, enhancing grid stability and reducing electricity costs at peak hours. Another solution is to produce hydrogen through electrolysis and use it to power a stationary or vehicle fuel cell to produce electricity during times of low power production or peak demand.

DOE and the national labs play a critical role in leading the early-stage scientific research and analysis needed to ensure that future mobility solutions maximize benefits for society and the economy while fostering a diverse domestic energy supply. NREL is working collaboratively with organizations including federal, state, and regional transportation agencies, and the lab is exploring opportunities to construct a dedicated facility to further enhance the nation's capabilities in this burgeoning arena.

Accelerating Introduction of the Next Generation of EDVs

EVs use only one-third as much energy per mile driven as conventional vehicles. Since hybrid electric vehicles' (HEVs') commercial introduction in 1999, more than 3 million

HEVs and more than 490,000 EVs have been sold, and automakers are rolling out new models at a record pace. Even with this encouraging growth in adoption rates, there are still barriers to overcome before we can expect EDVs—EVs, HEVs, plug-in HEVs, and fuel cell electric vehicles (FCEVs)—to dramatically decrease our nation's overall energy consumption.

NREL and the national labs have played a pivotal role in providing fundamental science and engineering expertise to spur the development and commercialization of EDVs. In 1993 NREL and DOE recruited the Big Three automakers—General Motors, Chrysler, and Ford—as partners to identify the most promising component technologies and system configurations, leading to some of the world's first production-feasible HEV prototypes. Principles established in the course of NREL's original research continue to guide EDV designs, and modeling and simulation software tools created by the lab are still being used by engineers across the country.

The lab has also played a critical role in the advancement of FCEV vehicle and infrastructure technologies. FCEVs offer the benefits of zero vehicle emissions, along with a driving range of more than 300 miles and a lightning fast refueling time of three minutes. However, even with FCEV models becoming commercially available in recent years, development of hydrogen fueling infrastructure is still in its infancy, and additional research is needed to address key remaining cost and performance barriers.

Charging infrastructure, battery technology, and affordability are three major, interrelated challenges to greater EDV adoption that NREL and DOE research is working to resolve. Most EVs cannot travel as far on a single charge as conventional vehicles do on a tank of gas, and charging stations are often fewer and farther between.

NREL and DOE are working in partnership with national labs across the country to identify the technical, infrastructure, and economic requirements for establishing a national extreme fast charging (XFC) network for EVs. In addition, we are exploring managed and wireless charging options that can eliminate some of the time and logistics constraints imposed by traditional plug-in charging and integrate with the electrical grid to balance loads. The labs are also working to validate infrastructure components and fueling protocols that can support a larger network of hydrogen fueling stations for FCEVs.

Connected to the charging issue are the performance and cost of batteries, which are the most expensive EV components. Research to drive down battery cost and size, while improving range, safety, lifetime, and performance is key to making EVs accessible to larger numbers of consumers. NREL research and award-winning innovations such as the Battery Internal Short-Circuit Device and Isothermal Battery Calorimeters are making it possible to accurately pinpoint and fix battery overheating

problems that can lead to safety issues.

Finally, while EDV prices continue to drop and new models provide a wide range of style and performance options, the additional upfront cost continues to pose impediments to broader adoption. That is why a major focus of our early-stage research is technology that will help EVs attain cost parity with conventional vehicles.

The lab continues to innovate in partnership with automakers and component suppliers to refine technology, boost performance, lower cost, and enhance appeal of EDVs. The NREL-led Computer-Aided Engineering for Electric-Drive Vehicle Batteries (CAEBAT) project involves collaboration with other national labs and industry leaders such as Ford, GM, and Johnson Controls in accelerating the development and lowering the cost of EV batteries with new computational and simulation tools. Work with partners such as John Deere, Wolfspeed, and Toyota USA as part of the DOE-sponsored Manufacturing Innovation Institute is pointing the way toward wide-bandgap semiconductor materials for EV power electronic devices that are smaller and more efficient.

In the last five years, NREL's early-stage scientific breakthroughs in EV battery and power electronics technologies have been recognized with three R&D 100 Awards, known as the "Oscars of Innovation." Eventually, these more recent innovations will make their way into vehicles in the marketplace, delivering efficiency, performance, and cost improvements for consumers.

Building Momentum for Maximum Efficiency in Freight Operations

More than $13 trillion in goods, equivalent to two-thirds of our entire gross domestic product (GDP), are shipped across U.S. roads each year. With fuel costs amounting to 40% of truck freighting expenses, greater fuel efficiency could save commercial fleet operators hundreds of millions of dollars, create hundreds of thousands of new jobs, and spur an overall $10 billion increase in America's annual GDP.

Independently, commercial truck electrification, automation, and connectivity promise to be major game changers. Collectively, these innovations can revolutionize freight mobility. DOE and NREL are taking a total-systems approach that combines vehicle battery advances with exploration of how a highly efficient in-road charging network might deliver productivity, performance, and operational benefits.

Connected and automated trucks could significantly decrease the cost of moving goods. Optimization of EV technology for heavy- and medium-duty vehicles, along with development of fast wireless charging will be key factors in meeting cost and operational targets by diminishing battery expenses and reducing the downtime required to charge freight vehicles. Integrating data on freight movement with vehicle connectivity and automation holds great potential to make the transfer of freight from

heavy-duty trucks to other modes of transportation—including delivery vans, trains, ships, or even possibly drones—more efficient.

Platooning systems for freight trucks reduce aerodynamic drag and safely decrease the distance between vehicles, allowing multiple vehicles to accelerate or brake simultaneously. These systems incorporate vehicle-to-vehicle communications, radar-based forward object detection, and active braking systems. NREL researchers, in partnership with organizations such as Peleton, have discovered that this relatively low-cost technology can be used on existing vehicles to deliver fuel savings of close to 10%.

Even though manufacturers such as Cummins and Tesla have announced plans for electric trucks, these early models will only serve niche applications. Significant R&D is still needed to adapt EV technology for trucks across the wide range of vocations that comprise the commercial trucking fleet as a whole.

DOE and NREL are exploring fuel cell and battery strategies for truck electrification that could substantially reduce fuel expenses, lower maintenance costs, and reduce emissions. Although technology and infrastructure for medium- and heavy-duty EVs, HEVs, and FCEVs still have a long way to go, battery and operating cost reductions are moving freight operations closer to the 3–4 times efficiency improvements typically delivered by electric drivetrains.

NREL has long been considered a leader in medium- and heavy-duty vehicle research, with evaluations of vehicles, infrastructure, operational practices, fuel-saving alternatives, and implementation considerations, combined with analyses using validated data from field-based measurements that factor in the multitude of variables needed to ensure meaningful benefits for large-scale freight operations. In addition to work focusing on EV, HEV, and FCEV technologies, researchers are also working to maximize efficiency and performance of hydraulic hybrids, as well as biodiesel and natural gas-powered medium- and heavy-duty vehicles.

The lab has forged strong partnerships with industry leaders including Bosch, Cummins, Volvo, Parker Hannifin, Smith Electric, Navistar, and Odyne, along with fleet operators, to make sure that scientific research is addressing key national-scale challenges. DOE and the lab hope to establish additional forums and facilities to leverage the collaborative expertise of these government, research, and industry partners.

The Need for Big Data, Analytics, and High-Performance Computing

Optimizing technology solutions for a complex interconnected transportation system requires utilizing and coordinating massive amounts of information with new high-speed computational modeling and simulation tools. While this data explosion is already transforming transportation, maximizing mobility and energy productivity calls for new

robust and efficient techniques to capture, store, analyze, and execute in real time.

Additionally, accurate and faster-than-real-time models of integrated transportation networks for large metropolitan regions are needed to direct, coordinate, and schedule the movement of people and goods. NREL and DOE are exploring new approaches to pave the way for these groundbreaking changes through fundamental advances in big data, analytics, machine learning, high-performance computing (HPC), and optimization/control theory.

NREL already offers the nation's most credible and complete transportation energy efficiency clearinghouses for validated and up-to-date statistics, data analysis, and tools, pairing information from government and private sector partners with expertise in analysis and applications. The data-driven insight and decision-making capabilities facilitated by NREL's robust arsenal of integrated tools help industry partners overcome technical barriers and accelerate the development of advanced transportation technologies and systems that maximize energy savings and on-road performance while reducing operating costs.

NREL's portfolio of databases—Fleet DNA, Transportation Secure Data Center (TSDC), National Fuel Cell Technology Evaluation Center (NFCTEC), and Alternative Fuels Data Center (AFDC), to name a few—feature real-world, on-road transportation and energy systems data and contribute to numerous R&D activities. Coupled with these world-class data resources and capabilities is NREL's wide assortment of models and tools that enable users to perform a wide array of tasks—evaluate real-world vehicle efficiency, compare powertrains, assess component improvements, use real-world data, or simulate representative drive cycles evaluating systems and components, compare battery-use strategies, and much more.

Conclusion

Yes, significant improvements to vehicle efficiency are underway, and concurrent advances in connected and automated technologies are rapidly transforming America's transportation ecosystem. Passenger vehicle fuel economy has improved significantly in recent years. Today's drivers can choose from EV, HEV, and optimized gasoline-fueled models with a range of automated features. Ride-sharing services make it possible to hail a car, track its arrival, and pay the fare with just a tap on a smartphone app. The Internet of Things is enabling connectivity and communications among drivers, vehicles, roadways, charging systems, transit networks, buildings, the utility grid, and more.

Research breakthroughs have helped make this possible, and marketplace competition continues to drive industry to embrace innovation. That said, we still have a long way to go, and DOE, NREL, and the national labs are working hard to push efficiency even further. Expanded automated vehicle capabilities could deliver even more convenient

and affordable mobility options. More extensive vehicle electrification and charging infrastructure could drive down costs and boost efficiency. Introduction of more commercial FCEVs and hydrogen stations could result in a truly zero-emission fleet.

At the same time, we need to bridge from existing transportation resources. Americans will keep driving vehicles powered by internal combustion engines for years to come, so let's work to make them as efficient and clean as possible. Our nation also has an abundance of domestic natural gas and biomass reserves that should be more effectively leveraged to provide additional transportation options.

We will continue to build on our existing relationships to advance this vision, including DOE public-private partnerships such as U.S. DRIVE (Driving Research and Innovation for Vehicle efficiency and Energy) and the 21st Century Truck Partnership.

DOE, NREL, and the other national labs will remain dedicated to pursuit of innovations that promise substantial benefits to consumers and businesses, with new fundamental science and sophisticated systems-level technology integration to ensure that widespread adoption provides maximum affordability, reliability, and security benefits.

Mr. SHIMKUS. Thank you. Now I would like to turn to Dr. Linn. You are recognized for 5 minutes and again thank you for being here.

STATEMENT OF JOSHUA LINN

Mr. LINN. Thank you distinguished members of the subcommittee for inviting me to speak today. My name is Joshua Linn. I am an Associate Professor in the Department of Agricultural and Resource Economics at the University of Maryland and a senior fellow at Resources for the Future, a nonprofit and nonpartisan environmental economic think tank. The views I express today are my own.

New technologies are fundamentally changing the vehicles people buy and the way they travel. Each year, passenger vehicles become more efficient, safe, and fun to drive. New car buyers can choose among an expanding number of vehicle options. Information technologies continue to create new travel options such as ride sharing or ride-hailing services and bike share programs.

The future may bring ever increasing levels of automated driving. These are exciting technological developments, but their implications for energy security and the environment are complex. My central point today is that these innovations benefit the U.S. economy and that well-designed policies can foster innovation while ensuring that societal objectives are met. I will make several specific points based on observations of recent consumer and automaker behavior.

First, tightening standards for fuel economy and greenhouse gas emission standards have imposed costs on both automakers and consumers. Following a long period of constant fuel economy standards, the National Highway Traffic Safety Administration and EPA have been tightening these standards. My research suggests that consumers undervalue recent improvements in fuel economy.

Over the past decade, automakers have gradually raised fuel economy to meet tightening standards. Based on data covering about a half million recent new vehicle buyers between 2010 and 2014, on average, consumers are willing to pay only about $50 for $100 worth of fuel savings. The fact that consumers do not want to pay the full hundred dollars implies that automakers cannot pass on all the costs to consumers.

The regulatory agencies assume that when automakers adopt fuel-saving technology, they raise vehicle prices sufficiently to cover costs. But if consumers only pay half the value of the fuel savings and the technology costs more than consumers are willing to pay, automakers can't raise prices sufficiently to cover costs without harming their sales. Thus, undervaluation implies the cost of tighter standards are borne by both consumers and automakers.

My second point is that tighter standards have affected vehicle horsepower and other attributes as well as fuel economy. An automaker raises the vehicle's energy efficiency when it adopts fuel-saving technology. The automaker can then decide whether to use the additional efficiency to boost fuel economy, horsepower, or both.

Typically, consumers are willing to pay more for horsepower than for an equivalent amount of fuel economy. Consequently, in the 1990s and 2000s when standards were changing, or not changing,

automakers adopted fuel-saving technology and added the efficiency, and used the efficiency to boost horsepower and increase vehicle size without affecting fuel economy.

During that time, horsepower tended to improve about 2 percent per year on average. Then, when standards began tightening, automakers used those energy-saving technologies to boost fuel economy rather than horsepower. In other words, consumers are foregoing the horsepower improvements under tighter standards that would have occurred if the standards had been left untightened. These foregone improvements appear to be costing consumers several billion dollars per year as compared to about $20 billion in fuel savings that they are getting from the higher fuel economy.

The third point is that so far the total cost of the standards appear to have been modest. The costs are difficult to observe, but research by my RFF colleagues suggest that marginal costs may have been $40 to $60 per metric ton of carbon dioxide, based on trades of compliance credits. These numbers are suggestive, but they are also modest because they are comparable to previous estimates of the social cost of carbon dioxide or the fines paid under the fuel economy standards for noncompliance.

The tightening standards for vehicle fuel economy and greenhouse gas emissions have induced technology adoption and probably some innovation. The automobile industry has demonstrated quite a lot of ingenuity which has kept the total cost of the standards to a modest level. As long as standards continue to provide automakers flexibility to figure out the best compliance strategies, I fully expect these patterns to continue in the future.

The fourth point is that gasoline-powered vehicles are likely to continue dominating the market for some time. Many policies incentivize consumers to buy or lease plug-ins. These policies combined may amount to $10- to $20,000 per vehicle of direct subsidies or indirect subsidies that may be funding charging infrastructure and the like. Nevertheless, consumers appear to continue buying, preferring gasoline powered vehicles. Declining battery costs and other innovations will surely increase the plug-in market share, but just how much is difficult to say.

Finally, new information technologies are transforming the way people travel. This is generally reducing travel costs and likely to increase total travel as well as total vehicle use. Fortunately, these changes can be addressed by adjusting the way that the standards are set. Right now, they provide equal incentives for changes in fuel economy regardless of how much the vehicle is driven allowing for that possibility that vehicles are driven different amounts would correct this inefficiency of the standards that has existed all along, but which these changes in travel may be exacerbating.

So again I want to thank you for inviting me to speak today and look forward to your questions.

[The prepared statement of Mr. Linn follows:]

Statement of Joshua Linn

Associate Professor, University of Maryland

Senior Fellow, Resources for the Future

To be presented to:

The House Committee on Energy and Commerce, Subcommittee on the Environment

The Future of Transportation Fuels and Vehicles

March 7, 2018

Thank you, Chairman Shimkus, Ranking Member Tonko, and distinguished members of the Subcommittee, for inviting me to speak today. My name is Joshua Linn. I am an Associate Professor in the Department of Agricultural and Resource Economics at the University of Maryland, and a Senior Fellow at Resources for the Future (RFF), a nonprofit and nonpartisan environmental economics think tank.[1] My research focuses on how consumers choose their vehicles and how much to drive, and how automakers choose technology.

New technologies are fundamentally changing the vehicles people buy and the way they travel. Each year, passenger vehicles become more efficient, safe, and fun to drive. New car buyers can choose among an expanding number of plug-in vehicles, in addition to the more familiar gasoline, hybrid, and diesel options. Information technologies continue to create new travel options, such as ride-sharing services and bike-share programs. The future may bring ever-increasing levels of automated driving, further benefiting consumers. At the same time, policies to promote innovation and new technologies exist at both federal and state levels—including standards for vehicle fuel economy and greenhouse gas emissions, tax credits for plug-ins, and subsidies for infrastructure and research.

These are exciting technological developments, which will benefit the US economy. However, their implications for energy security and the environment are more complex.

[1] RFF is an independent, nonprofit research institution focused on environmental, energy, and natural resource economics and policy. The opinions I express today are my own, and represent positions of neither the University of Maryland nor RFF.

On the one hand, innovations that reduce fuel consumption help us improve energy security and the environment. New information technologies make the transportation system more efficient. On the other hand, these same technologies may lead to more driving, higher fuel consumption, and increased emissions. Fortunately, well-designed policies can simultaneously foster innovation that benefits society while meeting energy and environmental policy objectives.

I'll make three additional points:

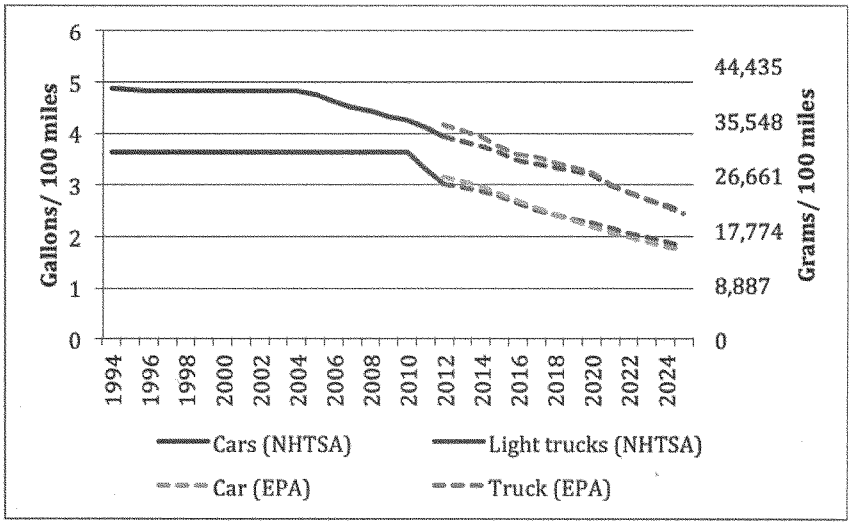
1. *So far, tightening standards for fuel economy and greenhouse gas emissions have imposed modest costs on automakers and consumers, and benefits likely exceed the costs.* Consumers do not appear to fully value the fuel cost savings from higher fuel economy, causing automakers to absorb some of the costs of the standards. Tighter standards have driven technology adoption and affected vehicle attributes other than fuel economy, such as horsepower.
2. *Gasoline-powered vehicles are likely to continue dominating the market for some time.* Presently, subsidies are largely driving the plug-in vehicle market. In the future, declining battery costs and improving vehicle quality will surely boost sales, but it is very difficult to say how much and how quickly.
3. New travel options are changing how people get around. *Adjusting the structure of fuel economy and greenhouse gas standards to reflect vehicle usage can ensure that policy objectives continue to be met.*

Background: Greenhouse Gas Standards

To provide historical context, Figure 1 shows the fuel economy standards (managed by the National Highway Traffic Safety Administration, NHTSA) and greenhouse gas emissions standards (administered by the Environmental Protection Agency, EPA) for cars and light trucks from 1994 through 2025. These standards were essentially flat between the late 1980s and the mid-2000s, and average fuel economy and greenhouse gas emissions rates did not change much during those years. Standards have been tightening since 2005 for light trucks and 2011 for cars, meaning higher fuel economy, lower fuel consumption rates, and lower emissions.

Under current regulations, fuel economy would roughly double between 2011 and 2025. That's a dramatic change after a long period of stasis.

Figure 1. Fuel Economy and Greenhouse Gas Standards, Historical and Projected



Source: Leard and McConnell (2017).

Consumer Demand for Fuel Economy

Tighter standards cause automakers to adopt fuel-saving technology, increasing fuel economy and reducing greenhouse gas emissions. In this section and the next, I focus on gasoline-powered vehicles, which currently account for about 99 percent of the US market. Here, I discuss how fuel-saving technology affects consumers.

Suppose an automaker increases a vehicle's fuel economy without changing anything else about the vehicle, and the higher fuel economy saves the consumer $100 in fuel costs over the vehicle's life. If the consumer is willing to pay less than $100 for the increase in fuel economy, *undervaluation* is at play—the consumer undervalues the cost savings from higher fuel economy.

Undervaluation has important implications for how standards affect consumers. Suppose that the technology costs $90 and saves consumers $100 in fuel costs. If consumers are willing to pay less than $90 for the technology, the automaker won't be able to recoup its related costs and it won't add the technology. That's a market failure because society would be better off if the automaker raises fuel economy; the value of the fuel savings ($100) exceeds the cost of the technology ($90). This market failure is often referred to as the energy efficiency gap, or energy efficiency paradox.

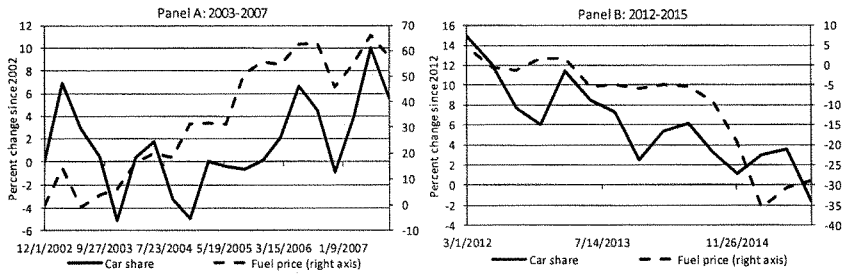
Because of this market failure, standards for fuel economy (or greenhouse gas emissions) could make consumers better off. Essentially, standards "correct" the mistake that consumers make and compel automakers to offer higher fuel economy. In other words, undervaluation would provide a justification for regulating fuel economy and greenhouse gas emissions, even if one ignores the societal costs of fuel consumption and emissions (for example, regarding energy security, climate, etc.).

The EPA and NHTSA claim that this market failure exists. Their argument is largely based on the observation that automakers do not appear to adopt fuel-saving technologies as quickly as one would expect, given the estimated costs and fuel savings of those technologies. As summarized in a few reports by the National Research Council, an extensive literature analyzing technology costs and fuel savings supports this argument.[2]

There's also quite a lot of evidence that gas prices affect consumer vehicle choices.[3] When gas prices go up (like they did in the mid-2000s), consumers shift from new light trucks to new cars; when gas prices go down (like they did between 2014 and 2015), consumers shift from new cars to new light trucks. Figure 2 depicts these patterns, and recent research has shown that gas prices affect consumer choices among individual vehicle models as well.

[2] For example, see National Research Council (2015).
[3] Many studies demonstrate strong links among gasoline prices, new vehicle purchases (e.g., Klier and Linn 2010), scrappage of older vehicles (Jacobsen and van Benthem 2015), and overall fuel economy of the on-road fleet (Li et al. 2009).

Figure 2. Fuel Prices and Market Share of New Cars (Percent Changes)



Source: Calculations using data from Wards Auto and US Bureau of Labor Statistics.

The fact that sales respond to gas prices is relevant, but it does not exactly answer whether consumers undervalue fuel economy. This is a harder question to answer—and up until a few years ago, the evidence was all over the place.[4] Then, based on gasoline price changes in the 1990s and early 2000s, several high-quality studies concluded that consumers fully or nearly fully value fuel economy, for both new and used vehicles.[5]

However, newer evidence suggests that consumers undervalue recent improvements in fuel economy. Over the past decade, automakers have gradually added fuel-saving technology and raised fuel economy to meet tightening standards. For example, between 2013 and 2014, Honda installed a continuously variable transmission in the Honda Civic EX-L, which raised fuel economy from 31.5 miles per gallon to 32.3. (This type of transmission matches the engine and wheel speeds more efficiently than a conventional transmission.) Many other examples like this one exist, and we can ask how much consumers typically pay for the higher fuel economy. Based on data covering about a half million recent new vehicle buyers between 2010 and 2014, on average, consumers pay about $50 for $100 of fuel savings.[6] Note that consumers get the full benefit of the higher fuel economy, by way of lower fuel costs—it's just that they're not willing

[4] See Helfand and Wolverton (2009) for a review of the literature.
[5] See Busse et al. (2013), Allcott and Wozny (2014), and Sallee et al. (2016).
[6] See Leard et al. (2017).

to pay for the full value of the savings. This may be because they're not aware of the savings, or for other reasons.

Consumer undervaluation suggests that fuel economy standards can address the market failure for fuel economy. It also implies that automakers have a hard time passing on the costs of the standards to consumers. The EPA and NHTSA assume that when automakers adopt fuel-saving technology, they raise vehicle prices sufficiently to cover costs. But if consumers only pay half the value of the fuel savings, and the technology costs more than consumers are willing to pay, automakers have a difficult choice to make. The first option is to raise vehicle prices to cover their costs. This would cause consumers to choose other vehicles, because they don't think the price increase is worth the fuel savings (even though it is actually worth the savings). Vehicle sales and profits would decrease. The other option is to raise vehicle prices by the amount consumers are willing to pay, absorbing the difference between the technology costs and price increase. For example, if it costs $90 to raise fuel economy enough to save consumers $100, automakers will raise vehicle prices to cover $50 of those costs, incurring a loss of $40. In either case, automaker profits decrease. Thus, undervaluation implies that the costs of tighter standards for fuel economy are borne by both consumers and automakers.

Fuel-Saving Technology, Vehicle Attributes, and the Costs of Greenhouse Gas Standards

This section considers the total costs of the greenhouse gas standards. I'll discuss how the standards affect automaker technology choices, and summarize some recent evidence on the costs of the standards.

An automaker that adds fuel-saving technology to one of its vehicles must decide how to integrate that technology and choose the vehicle's fuel economy and horsepower. Suppose an automaker has a vehicle for which it is considering adding fuel-saving technology. For example, a technology called cylinder deactivation can improve the efficiency of large engines by shutting off some of the cylinders when the vehicle is under light load. Automakers have recently added this technology to many light trucks, but let's suppose that the particular vehicle in this example does not have it. Typically, we think that when the automaker adds a technology such as this one, it uses the technology to raise fuel economy, while leaving other attributes (such as horsepower) unchanged. But it doesn't have to do this. Instead, the automaker can add the technology, and

then make further changes to the engine or transmission that effectively result in higher horsepower without changing fuel economy (compared to the initial vehicle). In other words, the automaker improves the vehicle's efficiency when it adds the fuel-saving technology. The automaker can decide whether to use the additional efficiency to boost fuel economy, horsepower, or both.

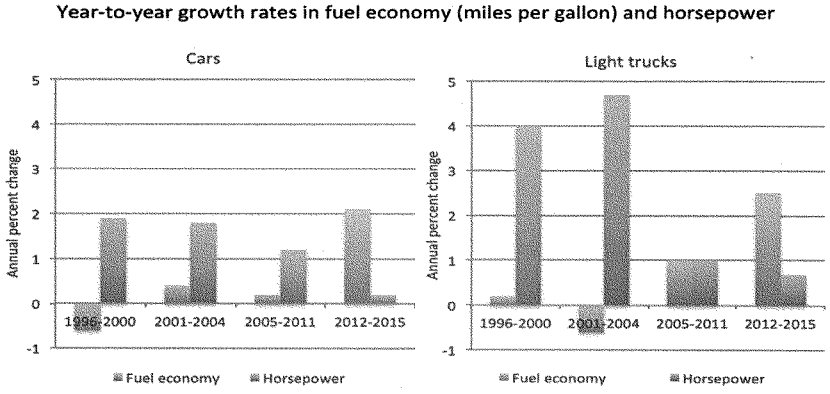
Given this flexibility to choose between horsepower and fuel economy, what do automakers actually do? Typical consumers are willing to pay more for horsepower than for an equivalent amount of fuel economy. Consequently, during times when the standards weren't changing, automakers adopted fuel-saving technology and used the added efficiency to boost horsepower while leaving fuel economy unchanged. For example, the National Museum of American History has an early version of the Honda Civic from the 1980s—it was tiny compared to today's Civic. The early Civic and today's version get similar levels of fuel economy, but today's Civic is much larger and has roughly double the horsepower because of all the technology that Honda has added over the past 30 years.

However, tighter standards change the automaker's incentives. With tighter standards, when an automaker adds technology it now has a greater incentive to use the technology to boost fuel economy. Therefore, with tighter standards, automakers are more inclined to use fuel-saving technology to boost fuel economy than when standards are held constant.

Figure 3 shows exactly these patterns, illustrating changes in horsepower and fuel economy for cars and light trucks, between 1996 and 2015. Standards for cars didn't change from 1996 through 2011, and during that time automakers raised horsepower by about 2 percent per year on average, leaving fuel economy basically unchanged. Then, when standards began tightening in 2012, fuel economy increased 2 percent per year, and horsepower didn't change at all. Light trucks show a similar patter, where the standards began tightening in 2005. Essentially, tighter standards caused fuel economy to improve rather than horsepower, implying that tighter standards caused consumers to forgo the horsepower improvements they would have enjoyed if standards hadn't tightened. Several recent studies quantify the magnitude of these costs to

consumers from the forgone horsepower improvements, finding them to be on the order of several billion dollars per year (compared to fuel savings of roughly $20 billion per year).[7]

Figure 3. Historical Changes in Fuel Economy and Horsepower



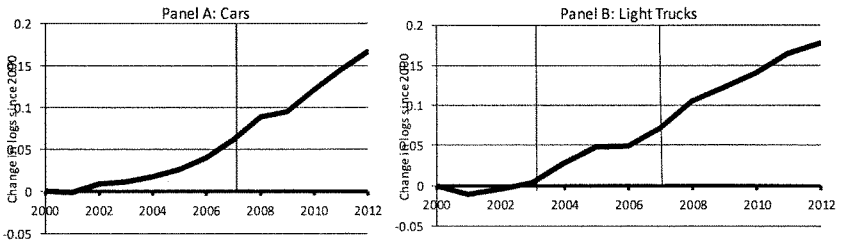
Source: Calculations from Wards Auto data.

Tighter standards also cause automakers to adopt fuel-saving technology more quickly. Adding technology raises vehicle costs, and when standards are unchanging automakers add technology if they think consumers are willing to pay for the higher horsepower (or other attributes). When standards are tightening, they create an additional incentive for automakers to add fuel-saving technology. Consequently, we expect more technology adoption when standards tighten.

This also seems to be happening. Figure 4 shows percent changes in power train efficiency for cars and light trucks since 2000. Efficiency is defined to include both fuel economy and horsepower changes, as well as other attributes related to fuel economy (such as weight). The vertical lines show the periods in which new standards were created for cars and light trucks. In both cases, after the standards tighten, the curve gets steeper, implying faster technology adoption and efficiency improvements. For example, efficiency of cars improved by about 1 percent per year before the standards tightened, and 2 percent per year after they tightened.

[7] See Klier and Linn (2016) and Leard et al. (2017).

Figure 4. Percent Changes in Power Train Efficiency for Cars and Light Trucks Since 2000



Source: Adapted from Klier and Linn (2016).

To summarize, tighter standards have increased the rate of technology adoption and caused consumers to forgo horsepower improvements. These changes imply costs, but just how large are those costs?

Under the new standards, which allow automakers to trade compliance credits, the credit price is proportional to the costs (i.e., the marginal costs) of the standards. For example, for an automaker selling emissions credits, the credit price is at least as high as the marginal cost of reducing emissions; otherwise, the automaker would be losing money by selling credits. A recent study by my RFF colleagues suggests that these credit prices have been modest; about $40 per metric ton of carbon dioxide, or (equivalently) about $100 per mile per gallon per vehicle.[8] I consider these costs to be modest because they're comparable to previous estimates of the social cost of carbon dioxide or the fines paid under the fuel economy standards for noncompliance. In other words, even though the standards thus far impose costs on automakers and consumers, the benefits appear to exceed the costs.

Plug-In and Information Technologies

Because of their dominance in the US market, I've focused on gasoline-powered technologies thus far in my testimony. Yet plug-in vehicle technologies are gaining market share and could potentially replace gasoline-powered vehicles in the long term.

[8] See Leard and McConnell (2017).

A range of policies incentivize consumers to buy or lease plug-ins. Some subsidies directly reduce the cost of obtaining these vehicles (such as federal and state tax credits for purchasing them). Other subsides are indirect, such as publicly funded infrastructure for recharging plug-in vehicles (which reduces refueling costs). Importantly, California's Zero Emission Vehicle Program mandates a certain level of plug-in sales in California and across several other states that have joined the program.

Presently, plug-in vehicle sales depend on subsidies. Since 2011, when plug-ins first entered the US market, their market share has grown to about 1 percent. Automakers are regularly introducing new plug-ins, such as the Tesla Model 3. Direct subsidies are typically at least $10,000 per vehicle, and indirect subsidies could easily add a further $10,000 per vehicle.[9] Nevertheless, most consumers currently choose other vehicles.

The experience with hybrid vehicles may be instructive about what happens with plug-ins. With hybrids, each successive version was better than the one it replaced. The same should hold true with plug-ins, as vehicles become easier to operate and more enjoyable to drive. Battery costs will continue falling, bringing the cost of producing a plug-in closer to the cost of producing an otherwise comparable gasoline-powered vehicle. However, as we've seen with hybrids, the transition from one vehicle technology to another tends to be gradual.

Plug-in innovation benefits automakers and consumers, as well as society. Consumers benefit from better technologies and expanding vehicle options; automakers benefit from higher profits and lower costs of meeting standards for fuel economy and greenhouse gas emissions. Where society is concerned, compared to gasoline-powered vehicles, plug-ins consume less gasoline and also reduce emissions (this will be true especially in the future, as electricity generation becomes cleaner).

New information technologies are transforming the way many people travel. Technologies that enable ride-sharing services, such as Uber, offer consumers new transportation options. Numerous cities have bike-share programs. In some cities, private companies compete with the main program (for example the brightly colored dockless bikes that were recently sprinkled

[9] See Jenn et al. (2016) and Linn and McConnell (2017).

across Washington, DC). Many consumers take advantage of these new options, reducing their travel costs, travel times, or both. The benefits to consumers are quite large, perhaps billions of dollars per year for Uber users alone.[10]

In thinking about the future, we should be careful about getting caught up in the hype about these technologies. About 10 years ago, after decades of steadily growing vehicle use, it appeared that vehicle use was leveling off and even decreasing. Many observers argued that differences in driving behavior were causing these changes (such as millennials who do not own a car or even have a driving license). But it turns out that this slowdown in driving growth was temporary, and caused mainly by economic factors, especially slowing income growth and employment (largely due to the 2008–2009 recession).[11] That is, it's true that millennials drive less, but other factors were more important. By analogy, ride-sharing services are clearly affecting travel for many people, but it's unclear whether they'll ultimately affect travel far outside urban areas.

Although these new information technologies benefit consumers, the technologies have uncertain effects on energy security and the environment. Standards for fuel economy and greenhouse gas emissions aim to reduce fuel consumption and emissions. They target fuel consumption rates (gallons of fuel per mile of travel) or emissions rates (grams of carbon dioxide per mile). Total fuel consumption and emissions depend on not just these rates, but also miles traveled; for example, total fuel consumption equals the average fuel consumption rate, multiplied by total miles traveled. Therefore, if information technologies increase total travel, they could increase total fuel consumption and emissions.

We should expect information technologies, particularly ride-sharing services, to increase miles traveled. Individuals who would have previously used public transportation or walked may now prefer using Uber, Lyft, or other services. This would imply a shift in travel behavior to ride-sharing and away from non-vehicle travel. There could also be an increase in total travel. Some individuals who might have stayed home may now use a rideshare because of the lower travel costs. Lower travel costs benefit consumers, as they can now enjoy cheaper and less time-consuming travel. But, from a societal perspective, total fuel consumption and greenhouse gas

[10] See Cohen et al. (2016).
[11] See Leard et al. (2016).

emissions may increase. A similar argument would apply to fully automated vehicles in the future.

Implications of New Technologies for Federal Policy

I'll discuss two implications of these technological innovations for federal policy. First, the tightening standards for vehicle fuel economy and greenhouse gas emissions have induced a lot of technology adoption for gasoline-powered vehicles, making them more efficient and less costly for consumers. The standards have probably induced some innovation as well—technologies that wouldn't exist if it weren't for the standards. Technology adoption and innovation are no accident, as they are exactly what we expect to occur under flexible regulations that set standards for automakers and allow them to figure out how to comply. The automobile industry has demonstrated quite a lot of ingenuity, and that's helped keep the costs of the standards at a modest level.

Second, fuel economy and greenhouse gas emissions standards could be adjusted to account for changes in travel behavior and vehicle utilization. State and local policies will continue to affect how information technologies influence total vehicle use (for example, policies that encourage carpooling). But federal vehicle fuel economy and greenhouse gas emissions standards also play an important role. Right now, an automaker's fuel economy and emissions requirements do not depend on how much its vehicles are driven; all cars are subject to one set of standards and all trucks are subject to another set of standards. For example, suppose an automaker sells two types of vehicles, the first of which is typically driven 100,000 miles over its lifetime, and the second of which is typically driven 200,000 miles. A given fuel economy improvement to the high-mileage vehicle saves twice as much fuel as would the same fuel economy improvement for the low-mileage vehicle. Consequently, the automaker should be rewarded twice as much under the standards for improving the fuel economy of the high-mileage vehicle. But in fact, the standards create the same incentive for the two types of vehicles.

This inefficiency has always existed with the standards. It implies that automakers do not have the right incentives for choosing fuel economy across the vehicles in their fleets. Changes in travel behavior caused by information technology could exacerbate this inefficiency. Federal

standards could address it by crediting fuel economy improvements or greenhouse gas emissions reductions based on a vehicle's expected mileage.

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Mr. SHIMKUS. Thank you. The chair now recognizes Mr. Jeremy Martin and you are recognized for 5 minutes. Dr. Martin, I am sorry.

STATEMENT OF JEREMY MARTIN

Mr. MARTIN. Thank you very much. Chairman Shimkus, Ranking Member Tonko, and members of the subcommittee thanks for the opportunity to testify today.

As has been noted, it is an exciting time to work in transportation. We are entering a period of change more profound than any since the automobile era began a century ago. But while autonomous vehicles get a lot of the attention, changes in our fuels and vehicles also have important implications for our economy and our environment. So thanks for holding this timely hearing and inviting me to share my views.

The fuels of the future will be cleaner and more diverse and the transition to these fuels is already underway. Any examination of transportation fuels must start with oil. Petroleum-based fuels are the dominant source of global warming pollution in the transportation sector which recently surpassed the electricity sector to become the leading source of U.S. carbon dioxide emissions.

There is no path to climate stability that does not involve drastically cutting our oil use. The Union of Concerned Scientists has developed a plan to cut projected oil use in half in 20 years through improvements in efficiency and innovative clean fuels including electricity and advanced biofuels. The largest near-term opportunity to cut oil use comes from efficiency improvements which are not only important to the climate but also protect consumers from oil price volatility.

Oil price volatility remains a major risk. EIA's projections for a decade from now suggest that gasoline could cost anywhere from $2.19 a gallon to $5.21 a gallon, depending on the price of oil. This price risk is mitigated by the improving fuel efficiency of our fleet. No matter what the price of gas, consumers save because of cost-effective vehicle efficiency standards. The EIA forecasts that 10 years from now, thanks to these standards, the average driver will use a hundred gallons less to drive 10,000 miles than they do today. Using less oil is the best insurance against oil price volatility, so protecting vehicle efficiency standards is critically important.

But while oil is the largest part of the mix today, this is starting to change. For 50 years, from 1958 to 2008, oil supplied at least 95 percent of U.S. transportation energy. But oil's hegemony began as the last coal-fired steam locomotives were replaced with diesels and it ended when refineries and gasoline distributors adopted a 10 percent blend as the main source of gasoline.

Ethanol used as a high-octane blending component of gasoline is less expensive and less polluting than the fossil fuel alternatives. But the rapid scale up of corn ethanol to supply this fuel also had negative consequences, putting pressure on agricultural commodity markets, exacerbating water pollution associated with corn farming, and land conversion as corn acreage expanded to meet the new demand.

More recently, the growth of biofuels has come mostly from biodiesel produced from soybean oil and other lower value fats and oils, and biomethane, a waste-based transportation fuel that displaces fossil fuels while supporting the capture and destruction of methane, a potent climate pollutant. Cellulosic ethanol from corn kernel fiber and corn stalks is also growing, albeit more slowly than originally hoped.

Looking into the future, the importance of electricity as a transportation fuel is no longer a matter of dispute, although how quickly this transition occurs remains uncertain. Today, U.S. companies are leading the way on EV technology, but without the support of policies the U.S. will cede the field to economic competitors. This will not stop the inevitable transition to electric vehicles. However, this transition will take time and will proceed at different rates in different parts of the transportation sector. Petroleum and biofuels will remain an important part of our fuel mix for decades to come, so it is important to use them wisely.

Smart deployment of biofuels can support the progress of vehicle efficiency. The success of E10 demonstrates that ethanol is most valuable when it is used for its high-octane properties and the Co-Optima project shows the potential to build on this success. Automakers motivated by rising vehicle efficiency standards are currently putting engine technologies in the market such as turbocharging that would benefit from the deployment of high-octane fuels. However, until cost effective, high-octane fuel is reliably available, automakers won't sell cars with the higher compression and downsized engines required to realize the benefits of the co-optimized system.

Phasing in a new fuel gradually for use by optimized vehicles will avoid shocks to the agricultural commodity markets and extend the useful lifetime of investments of ethanol production while making even deeper cuts in oil use than will be possible if we remain stuck at the E10 blend wall. Policies to support fuels and vehicles of the future should focus on cutting oil use and supporting the growth and innovation in the cleanest vehicles and fuels and this work is far from done. Thank you.

[The prepared statement of Mr. Martin follows:]

Future of Fuels and Vehicles Testimony

Jeremy Martin, Ph.D. Senior Scientist and Fuels Lead, Clean Vehicles, Union of Concerned Scientists

Chairman Shimkus, Ranking Member Tonko, and members of the subcommittee, thank you for the opportunity to testify in front of this subcommittee today. The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems.

It is an exciting time to work in transportation. Experts agree that we are entering a period of change more profound than any since the automobile era began a century ago. But while autonomous vehicles are currently getting the most attention, changes in our fuels and vehicles also have important implications for our economy and environment, so thank you for holding this timely hearing, and for inviting me to share my views.

My recent report, Fueling a Clean Transportation Future, found that the fuels of the future will be cleaner and more diverse, and the transition to these fuels is already underway.

Any examination of transportation fuels must start with oil. Petroleum-based transportation fuels are the dominant source of global warming pollution in the transportation sector, which has recently surpassed the electricity sector to become the leading source of U.S. carbon dioxide emissions. There is no path to climate stability that does not involve drastically cutting our oil use.

The Union of Concerned Scientists has developed a plan to cut projected oil use in half in 20 years through improvements in efficiency and innovative clean fuels, including electricity and advanced biofuels. The largest near-term opportunity to cut oil use comes from efficiency improvements, which are not only important to the climate, but also protect consumers from oil price volatility at the pump.

Oil price volatility remains a major risk. Despite recent low oil prices, Energy Information Administration (EIA) projected that a decade from now gasoline could cost anywhere from $2.19 to $5.21 a gallon in 2017 dollars, depending on the price of oil. This price risk is mitigated by the improving fuel efficiency of our fleet. No matter what the price of gas, consumers save because of cost-effective vehicle efficiency standards. EIA forecasted that ten years from now, thanks to these standards, the average driver will use 100 gallons less to drive 10,000 miles than they do today. Using less oil is the best insurance against oil price volatility, so protecting vehicle efficiency standards is critically important.

But while oil is the largest part of the fuel mix today, this is starting to change. For 50 years, from 1958 to 2008, oil supplied at least 95% of U.S. transportation energy. Oil's hegemony began as the last coal-fired steam locomotives were replaced with diesels, and ended when refineries and gasoline distributors adopted a 10% ethanol blend as the main source of gasoline. Ethanol used as a high-octane blending component of gasoline is less expensive and less polluting than the fossil fuel alternative. But the rapid scale up of corn ethanol to supply this fuel also had negative consequences, putting pressure on agricultural commodity markets, exacerbating water pollution associated with corn farming, and land conversion as corn acreage expanded to meet the new demand.

More recently the growth of biofuels has come mostly from biodiesel, produced from soybean oil and other lower value fats and oils, such as animal fat, inedible corn oil extracted from distillers' grains, or used cooking oil. Biomethane is also a growing waste-based transportation fuel, captured at landfills, waste-water treatment plants, and diaries, it displaces fossil fuel while supporting the capture and destruction of methane, a potent climate pollutant. Cellulosic ethanol from corn-kernel fiber and corn stalks is also growing, albeit more slowly than originally hoped. The agriculture sector has a major stake in a low-carbon future that goes beyond ethanol, to other advanced biofuels and biomaterials, to bioenergy with carbon capture and storage. Landscapes that integrate existing crops with perennial

grasses and trees can increase carbon storage in soils and plants while enhancing profitability and protecting water quality and soil health.

Looking to the future, the importance of electricity as a transportation fuel is no longer a matter of dispute, although how quickly this transition occurs remains uncertain. The transition to electric vehicles (EVs) goes hand in hand with a transition to renewable power. Properly managed, EVs bring significant energy storage and demand flexibility to the power sector, providing grid services that save money not just for EV drivers, but also for other users of the grid. Today, U.S. companies are leading the way on electric vehicle technology, and, with supportive policy, the U.S. can continue to lead. Without supportive policies, the U.S. will cede the field to economic competitors, but will not stop the inevitable transition to electric vehicles.

But the transition to electrification will take time, and will proceed at different rates in different parts of the transportation sector. Petroleum and biofuels will remain important parts of our fuel mix for decades to come, so it is important to use them wisely.

Smart deployment of biofuels can support the progress of vehicle efficiency. The success of E10 demonstrates that ethanol is most valuable when used for its high-octane properties, and the Co-Optima project shows the potential to build on this success. Automakers, motivated by rising vehicle efficiency standards, are currently putting engine technologies in the market – such as turbocharging – that would benefit from the deployment of high-octane fuels. However, until cost-effective high-octane fuel is reliably available, automakers won't sell cars with the higher compression and downsized engines required to realize the benefits of the Co-Optimized system. There is no feasible deployment of optimized cars and appropriate fueling infrastructure sooner than 2026. Moreover, phasing in a new fuel gradually for use by optimized vehicles will avoid shocks to agricultural commodity markets, extend

the useful life of investments in ethanol production, and make even deeper cuts in oil use than would be possible if we remain stuck at the E10 blend wall.

Policies to support fuels and vehicles of the future should focus on cutting oil use and supporting growth and innovation in the cleanest vehicles and fuels. This work is far from done.

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Mr. SHIMKUS. Thank you very much. Now I would like to turn to John Eichberger, Executive Director of Fuels Institute. Welcome. You are recognized for 5 minutes.

STATEMENT OF JOHN EICHBERGER

Mr. EICHBERGER. Thank you Mr. Chairman. And good morning, committee. Thank you for having me here today.

Real quick about the Institute, we founded in 2013 and we are a nonprofit, collaborative, peer-reviewed research organization. We are unbiased. We do not advocate for any outcomes. Our goal is simply to deliver objective analysis of market conditions and trends to help decision makers make more informed decisions. That said, the comments I am delivering today are my own and they do not represent any specific position of anybody who is part of the Fuels Institute.

Let me start by noting I have read the written statements of all my co-panelists and there is almost nothing in their written statements with which I disagree. It is absolutely an exciting time to be part of this industry. There is so much going on. Every day there are new headlines and new reports to digest and analyze to where the market is heading. But the headlines don't always reflect reality and it is important to understand the fundamentals of the market if we want to appropriately anticipate the direction the market might be heading.

I truly do believe the electric vehicles will represent a majority of vehicles in the future. Where I differ with a lot of other people is the definition of when that future might arise, and this is not because I don't believe the viability of the technology. It is because I look at the size of the market and I know it is going to take time to make a significant change.

To demonstrate my point I do have a chart. It is in my written statement, but I will have it on the screen here in a minute too. I wanted to take a look to see how long it takes for the market to evolve and so what I did is I plotted if we were to introduce a new feature into every vehicle sold as of January 1st, 2017, how long would it take to get to a significant share of the market?

The numbers I ran using EIA forecast for sales and scrappage rates means it would take 7 years before that feature was present in 50 percent of the vehicles on the road. That is a long turnaround to get something on the market. By contrast, battery electric and plug-in hybrid electric vehicles sold 1 percent of the vehicles last year. They represent 1 percent of the vehicles sold last year.

So we have got a long way to go. And that sales rate in 2017 was a 26——

Mr. SHIMKUS. Will the gentleman suspend for a minute?

Mr. EICHBERGER. Sure.

Mr. SHIMKUS. Are we going to put his slide up?

OK, thank you.

Mr. EICHBERGER. Thank you, Mr. Chairman.

[Chart shown.]

Mr. EICHBERGER. So if you take a look, that is the chart rate in terms of if every vehicle had a new feature, 100 percent market conversion, 7 years to get a 50 percent market share. EVs were 1 percent of sales last year, there is a 26 percent growth rate over

2016. And this next chart, if I can have that one up, I wanted to find out what would happen if we continued an aggressive sales rate.

[Chart shown.]

Mr. EICHBERGER. So this plots a 26 percent and a 20 percent annual growth rate for battery and plug-in hybrid vehicles through 2035. This results in a potential market share of 43 percent of cars sold in 2035, but only 10 ½ percent of vehicles on the road. That is the size and scope of this market. It is going to take a long time. Even with aggressive sales it is going to take time to get some turnover, which means in 17 years 90 percent of the vehicles on the road will still be powered by an internal combustion engine and fueled with liquid fuels.

The size of the market is enormous. We must not lose sight of that. Of course there are many factors that could accelerate the pace of change as outlined in my written testimony. But regardless, the internal combustion engine is going to dominate the market for decades to come and we are already seeing that market evolve. Downsized engines, start-stop applications, boosted engines, compression ignition, hybrids, variable compression ratio engines, auto engineers are charting new advancements all the time overseeing the benefits yielded to consumers.

Among the top as it has gained a lot of attention recently over the last several years is to design an engine optimized to run on a specific higher-octane fuel. I have seen numerous technical reports indicating that this could provide a great benefit to efficiency, emissions, and performance for consumers. Fuels Institute, we have our own report coming out hopefully this May which seeks to answer some key questions about a high-octane fuel future.

These questions include how would we produce the fuel, what are the constituents that would go into building that fuel? What would be the cost and feasibility and scalability? What are the distribution issues? What is the anticipated level of demand for the new fuel and how long might it take to reach market maturity? There is potential here, but tradeoffs are probably going to be required and the transition is going to take time.

The vehicles and fuels market is changing. Engines and fuels will become cleaner, more renewable and more efficient, but all transitions take time. I urge the committee to be suspicious of any prediction of eminent disruptive change. Most are focused on one causal factor and dismiss the numerous other factors that will influence consumer decisions. Changing today's transportation system will not be like introducing the car engine that replaced the horse and buggy. It will not be like introducing the smart phone which transformed pretty much all commerce and social interaction as we know it.

Each example of a major, successful, disruptive event delivered compelling, immediate, and tangible value to the consumer that improved their quality of life in some real way and I question what options are we seeing in the transportation sector that could deliver similar value and cause transformative disruptive change? Whatever change is on the horizon, if the consumer cannot access it or does not want to buy it, it will not succeed and we wasted time and resources.

I believe change ultimately is coming, but for the foreseeable future the market is going to look remarkably similar to the market we have today and the transition to something different will be measured and incremental. Thank you very much for inviting me today.

[The prepared statement of Mr. Eichberger follows:]

Fuels Institute

Testimony of John Eichberger,

Executive Director, the Fuels Institute,

before the

House Energy and Commerce Committee's

Subcommittee on the Environment

at a hearing entitled,

"The Future of Transportation and Fuels,"

March 7, 2018

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Summary of Testimony

- The vehicles and fuels market will change, but absent significant influence from an external factor (such as government policy) it will likely take decades before major shifts in the composition of the vehicles on the road or the fuels that power them will be achieved.

- If every vehicle sold today were equipped with a new technology, it would take about seven years before the new feature is present in more than 50% of the vehicles on the road—and that is assuming 100% immediate and persistent market adoption.

- Even when assuming a very aggressive rate of growth in the sale of battery electric vehicles and plug in hybrid electric vehicles (at 26% annual growth 2017–2025 and 20% annual growth 2026–2035), these vehicles would combine for 42.9% of all LDVs sold in 2035. Yet, because of the overall size of the market, their combined share of registered LDVs by that time is only 10.4%.

- There are several external factors that affect these growth trajectories, including:

    - If oil prices go above $80 per barrel, retail fuel prices could accelerate consumer interest in alternative vehicles, including electric vehicles.

    - Global announcements to ban some internal combustion engines (especially in China) could hasten the drop in battery prices and incent the auto industry to increase electric vehicle production, thereby influencing the domestic market.

    - If fleets can realize a substantial decrease in annual operating expenses by shifting to electric vehicles, their bulk purchases could accelerate market transition and signal to consumers that these vehicles are viable options.

    - Urbanization introduces new complexities for personal mobility at a time when younger generations are moving to cities and are more open to alternative transportation paradigms. Electric, autonomous on-demand mobility services could become a less expensive and sought-after alternative to personally owned vehicles in some markets, but the system is unlikely to gain national reach in the near term.

    - Advancements in the efficiency of internal combustion engine design, potentially paired with a change in fuel specification, promise to benefit consumers by delivering more miles per dollar, thereby could slow the pace at which consumers may seek out alternative powertrains, like electric vehicles.

- Disruptive events must deliver compelling consumer value, reducing costs and friction in the market to such an extent that it leads to an improved quality of life. Absent such value, consumers are unlikely to rush to abandon traditional systems unless required to do so by an external force. Currently anticipated transportation options do not seem to offer such compelling value to result in transformative, disruptive change in the vehicle and fuels market. Consequently, change is likely to be incremental and take extended time.

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Statement of John Eichberger

Chairman Shimkus, Ranking Member Pallone, members of the Subcommittee, thank you for inviting me to share my perspective with you today regarding "The Future of Transportation Fuels and Vehicles." My name is John Eichberger and I am the Executive Director of the Fuels Institute. It is my pleasure to share with you my thoughts on the fundamental factors that might shape the future of the market.

About the Fuels Institute

The Fuels Institute, founded in 2013 by NACS (the trade association representing the international convenience and fuel retailing industry), is a 501(c)4 non-profit research organization focused on publishing peer-reviewed, unbiased research evaluating issues affecting the fuels and vehicles market today and in the future. Led by a diverse Board of Advisors, the organization does not advocate and has no vested interest in how the market develops. Research is commissioned to answer questions that decision-makers in the industry and government might have by providing data and perspectives that can lead to more informed decisions. In addition to publishing unbiased research, the Fuels Institute fosters cross-sector collaborative dialogue and provides common-sense analysis to the issues of the day. A list of our Board of Directors, Board of Advisors and contributing corporate partners and associations is available on our website and is reproduced in each published report.[1] A comprehensive list of our research published to date is available[2], and a monthly newsletter containing market analysis in blog-form[3] is also available.

[1] http://www.fuelsinstitute.org/about.shtm
[2] http://www.fuelsinstitute.org/research.shtm
[3] http://www.fuelsinstitute.org/news/fuelsforthought/index.shtm

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Disclaimer

The comments presented in this testimony reflect those of myself (John Eichberger) only and do not constitute an official position of the Fuels Institute. The comments have not been reviewed or approved by any contributing partner of the Fuels Institute or any member of the Board. They reflect my perspective of the market as the Executive Director of the Fuels Institute and have been guided by Fuels Institute research, conversations with diverse stakeholders, third party research and data, market analysis and my nearly 20 years of experience in the transportation energy sector. This testimony should not be construed to represent the position of an individual or organization contributing to the Fuels Institute, or serving on a Fuels Institute committee or research task group. My testimony should not suggest or infer that the Fuels Institute supports or opposes any legislative or regulatory initiative.

Overview

When evaluating the future of the transportation market, the headlines and forecasts that predict a rapid change in market structure and behavior can be overwhelming. It is important to take this type of information and view it within the context of the existing market to better understand the validity of the predictions. If I could leave you with one message today it would be this: The market will change, but absent significant influence from an external factor, such as government policy, it likely will take decades before major shifts in vehicle composition and the fuels that power them will be achieved.

This is not to dismiss advancements in vehicle technology or powertrain diversification; it is simply a recognition of the size and scope of the current market, the amount of time vehicles remain in service and the nature of human behavior.

Currently, there are nearly 250 million light-duty vehicles (LDV) registered in the United States. The U.S. Energy Information Administration (EIA) projects that an average of 16.6 million vehicles will be sold each year through 2030, and according to EIA's projections for the size of the fleet, approximately 6% of vehicles on the road will be scrapped each year.[4] What this means it that it will take time before a new technology penetrates the market in a meaningful way. In fact, using these statistics as the foundation, Figure 1 plots the rate of market penetration if a new feature were to appear in 100% of the vehicles sold as of January 1, 2017. As you can see, it would take about seven years before the new feature is present in more than 50% of the vehicles on the road—and that is assuming 100% immediate and persistent market adoption.[5] By way of comparison, total sales of battery electric vehicles (BEVs) and plug in hybrid electric vehicles (PHEVs) combined represented just 1.1% of LDVs sold in 2017.

[4] https://www.eia.gov/outlooks/archive/aeo17/
[5] http://www.fuelsinstitute.org/news/fuelsforthought/2017/Jun2017-2.shtm

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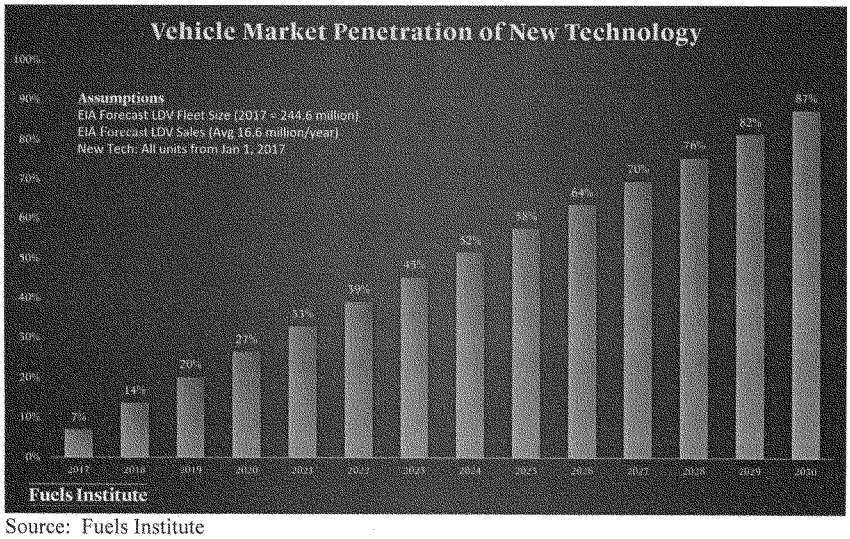
Figure 1. Vehicle Market Penetration of New Technology



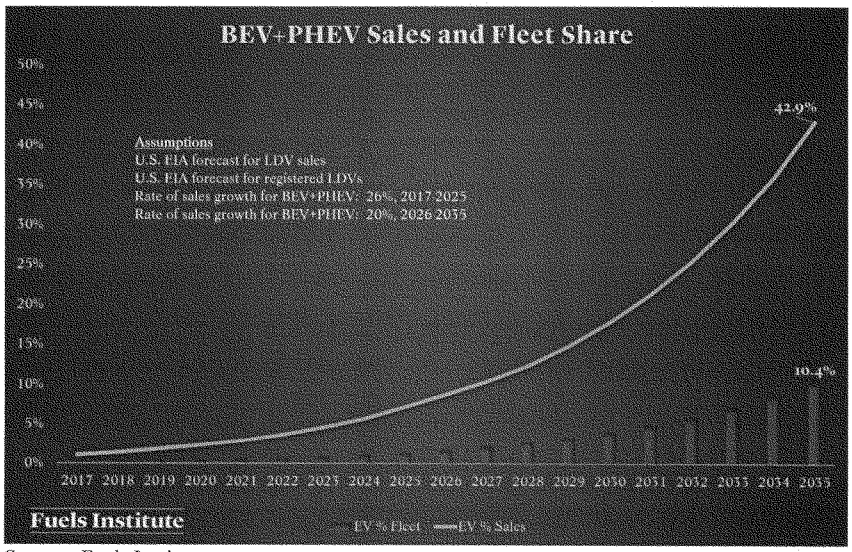
Source: Fuels Institute

Yet the rate of sales growth for these electrified powertrains has been impressive: 26% more BEVs and PHEVs were sold in 2017 than 2016, according to WardsAuto. I believe strongly that these powertrains (BEVs more so than PHEVs) will eventually represent most vehicles on the road, but where I disagree with many headlines and aggressive forecasts is the timing of that eventuality. I believe this future is several decades away because the rate of market conversion is much slower than the rate of vehicle sales growth.

To demonstrate, Figure 2 uses the same EIA data as Figure 1 and plots the share of LDV sales and registered LDVs for BEVs and PHEVs. For this illustration, the 26% rate of growth in BEV/PHEV sales recorded in 2016-2017 is extended annually through 2025. After then, however, because the overall market will have increased to a significant number rendering year-

over-year sales increases more difficult to achieve, the annual rate of growth is decreased to 20% through 2035. This remains a very aggressive forecast and results in BEVs and PHEVs combining for 42.9% of all LDVs sold in 2035. Yet, because of the overall size of the market, their combined share of registered LDVs by that time is only 10.4%. It should be noted also that in 2035, despite selling 7.5 million BEV and PHEV units, the United States will still incorporate into its existing fleet an additional 10 million units of traditional powertrain vehicles.

Figure 2. BEV+PHEV Sales and Fleet Share



Source: Fuels Institute

Factors That Might Affect the Rate of Market Transition

Figure 2 represents what I would consider to be a very aggressive rate of change in the composition of vehicle sales, yet it still affects only a modest change in the overall functioning of

the market. Nearly 90% of vehicles on the road will continue to be powered by liquid fuels in 2035, despite the growth in electrification. But there are external factors that could influence this projection, which may include:

- A sustained increase in crude oil prices
- Global regulatory developments
- Fleet vehicle purchases
- Urbanization, generational shifts and mobility as a service
- Advancements in the efficiency of internal combustion engines

In the following pages, I will explore how each of these factors could change the future of the vehicles and fuels market.

Crude Oil Prices

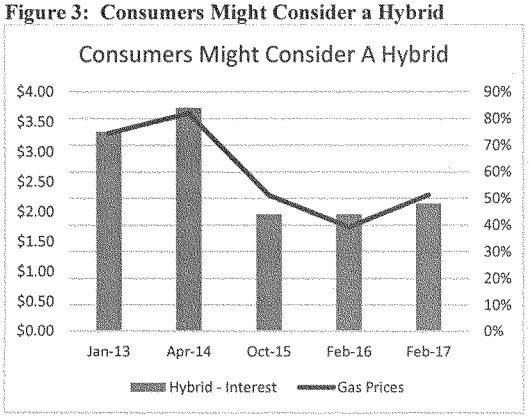
According to EIA, since 2010 crude oil prices have contributed on average 60% to the retail price of gasoline.[6] When oil prices rise, so do retail gasoline prices and that generates enhanced consumer sensitivity to prices. According to NACS, at the beginning of 2018, after multiple years of relatively low prices, two-thirds of consumers continue to select their fuel retail outlet based on the posted price of fuel, and 38% still say they might drive as much as 10 miles out of their way to save 5 cents per gallon.[7] However, when gas prices are higher, consumer sensitivity is higher and translates into greater interest in alternative fuel vehicles.

[6] https://www.eia.gov/petroleum/gasdiesel/gaspump_hist.php
[7] Upcoming release in March 2018 issue of *NACS Magazine*

Fuels Institute

Since 2013, the Fuels Institute and NACS annually ask consumers whether they are in the market to purchase a vehicle in the next few of years and, if so, whether they would consider certain alternative fuel/powertrain vehicles. As Figure 3 demonstrates, when retail fuel prices were above $3.50 in 2014, 84% of consumers said they would consider a hybrid vehicle. However, when fuel prices dropped to below $2.00 at the time of the survey in 2016, the percent of consumers who would consider a hybrid dropped to 44%. This level of sensitivity to gas prices and overall interest in alternative vehicles was demonstrated in overall sales of hybrids. Figure 4 shows that when fuel prices dropped, not only did interest in hybrids decline but actual sales did too—from 3.2% of all LDVs sold in 2013 to 1.9% in 2016.[8]

Figure 3: Consumers Might Consider a Hybrid



Source: OPIS, Fuels Institute, NACS

[8] www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Consumers-and-Alternative-Fuels-2017

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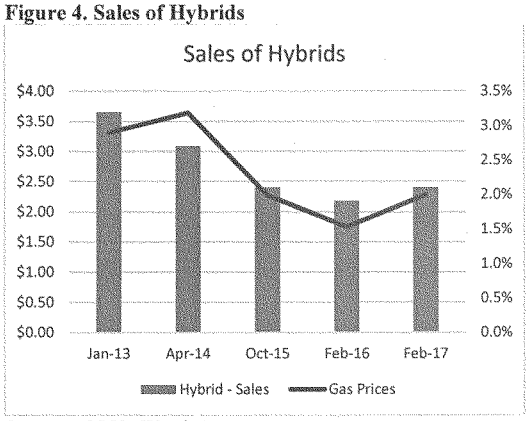
Figure 4. Sales of Hybrids



Source: OPIS, WardsAuto

While most forecasts are not projecting oil prices to eclipse $80 per barrel again anytime soon, if this situation were to develop the impact on retail fuel prices, and consequently interest in alternative vehicles, could be significant. Every time Brent oil has been priced above $80 since 2011, the national average retail price of gasoline has been above $3.00.[9] A sustained market position of these levels could encourage consumers to consider an alternative fuel vehicle that would deliver more miles per dollar.

Global Regulatory Developments

The automobile industry is global, with most automakers seeking to strengthen their economies of scale by introducing flexible vehicle architecture to satisfy multiple markets throughout the world. This means that activities in other countries could have residual impact on the United States. For example, recent announcements by several governments—including China, India,

[9] Brent oil price data sourced from U.S. EIA; retail fuel prices sourced from OPIS Retail Fuel Report

United Kingdom, France, Germany, Norway and even domestically in California–to ban internal combustion engines and mandate a transition to electric vehicles could have a profound impact on the manufacturing decisions of global automakers. Although most of these announcements exclude hybrid vehicles from proposed bans, the implications of such policies could be significant. For example, in 2016, Chinese consumers purchased 31.3% of the world's LDVs, which puts China in a position to exert significant influence on the automotive industry. Further, OPEC projects China and India combined will represent nearly 40% of global gross domestic product (GDP) by 2060. This is an economic power block that cannot be ignored when considering the future of the automotive industry.

To consider whether these nations will remain committed to their stated policy objectives, let's look at China. The Chinese government is stable and likely to remain in power for several decades, suggesting we might expect consistent policy throughout this timeframe. Further, China has a parochial interest in promoting electric vehicles since it currently produces a substantial share of the world's BEV batteries, and controls significant shares of the world's cobalt and lithium reserves. Should China proceed with a ban on internal combustion engines and a mandated transition to electric vehicles, battery costs for BEVs could decline rapidly due to increased production volume, and that automakers considering Chinese market opportunities will increase BEV production. This combination of lower costs and increased production could inspire larger deliveries of BEVs to the United States. The greater availability of potentially more affordable BEVs could increase the rate of consumer adoption of these alternative powertrains.

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In addition to these announcements, 159 nations have signed on to the Paris climate accords and are working to reduce overall emissions to meet their agreed-upon targets. To date, 60 nations are implementing some sort of biofuels program, 40 have a greenhouse gas reduction or fuel efficiency program, 20 contain jurisdictions that have enacted some sort of ban or limitation on internal combustion engines, 13 have established zero-emission vehicle zones, and nearly all have enacted fuel sulfur controls.[10] As nations continue to press forward with global commitments and local government focus their efforts to address air quality, policymakers will look at other markets for guidance and experience. This could result in additional initiatives considered within the U.S. that could disrupt the market trajectory.

Fleet Purchases

Fleet operators represent the potential to inject momentum for change through volume and by example. The Rocky Mountain Institute believes that fleet operators could reduce annual operating expenses by approximately $1,000 per vehicle.[11] For a fleet manager, who might be in the market to purchase 100 vehicles in a year, this could deliver $100,000 benefit to his bottom line—a powerful incentive to consider an electric vehicle. Given that modern BEVs can deliver more than 200 miles per charge, recharge in less than an hour and sell for a comparable price as an equivalent internal combustion engine, there is strong potential for fleets to purchase BEVs in larger quantities, contributing to an accelerated market penetration.

Because of a stronger presence of BEVs in the market, fleet adoption could signal to individual consumers that BEVs are viable. Human behavioral sciences suggest that consumers are drawn

[10] www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Global-Initiatives
[11] https://www.rmi.org/insights/reports/peak-car-ownership-report/

to items they are familiar with and used by their peers. If consumers witness fleet operators, who drive more miles per year than most consumers, opting for a BEV, they may be more inclined to consider a BEV. Hence, more rapid fleet adoption of BEVs could have a domino effect that would accelerate market conversion and support consumer adoption.

Urbanization, Generational Shifts and Mobility as a Service

Where people live, who lives there and how they get around can have a profound influence on the composition of the transportation market.

First, younger consumers in the United States behave substantially different than their predecessors. For example, younger consumers are much more inclined to consider an alternative vehicle. In fact, a 2017 Fuels Institute survey found that 66% of consumers age 18-34 would be willing to consider a BEV as their next vehicle, compared with just 47% of consumers age 35-49.[12] But perhaps more interesting is that since 1982, the percent of consumers age 20-29 who have a driver's license declined by 10% to just 81.5% of the cohort.[13] These trends are indicating a significant shift in consumer behavior relative to car ownership and driving.

Compounding this shift in behavior for the younger generation is the overall urbanization of society. The percent of Americans living in metropolitan areas has increased from 56% in 1950 to 84% in 2010. Since 1970, the percent of those age 20-34 who are living in these markets has increased from 33% to 40%, and the trend is continuing.[14] Americans are living in more

[12] http://www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Consumers-and-Alternative-Fuels-2017
[13] www.fuelsinstitute.org/forms/reportdownload.aspx?rid=Driver-Demographics
[14] www.fuelsinstitute.org/ResearchArticles/Urbanization%20Brief.pdf

concentrated, urban environments, which introduces unique mobility issues such as cost of insurance, parking, congestion and overall convenience.

Capitalizing on this trend have been ride hailing services. With mobility through an urban environment becoming more challenging, and with younger consumers less inclined to drive, mobility has gained significant traction. Most analysts agree that the typical American drives his or her vehicle approximately 5% of the time. The remaining time for that vehicle is spent absorbing resources for insurance, parking and depreciation. Using an on-demand mobility service can be attractive to many as an alternative to such burdens of vehicle ownership.

Deloitte research suggests that 23% of Americans report using a ride hailing service at least once per week, and this number jumps to 44% for Generations Y and Z. Of those in Generations Y and Z who use a ride hailing service, 64% question their need to own a car in the future.[15] Members of these generations know a market that included electric vehicles and do not have historic concerns about the technology. They are also looking for an alternative to driving and are accepting of new technologies and services.

Rocky Mountain Institute suggests that autonomous, electric vehicles could reduce costs of on-demand mobility services to such an extent that such services could become less expensive than owning one's own car.[16] RethinkX published a paper predicting that mobility services would be 10 times less expensive than owning a car.[17] And Deloitte predicts that by 2040, total LDV sales

[15] Ryan Robinson, Deloitte, presentation at Fuels Institute Annual Meeting, May 2017, Denver, CO
[16] https://www.rmi.org/insights/reports/peak-car-ownership-report/
[17] https://www.rethinkx.com/transportation

could drop to about 11 million per year, of which only about 4 million will be personally owned and driven vehicles, with the remaining a mix of on-demand services and personally owned autonomous vehicles.[18]

In November 2017, Bob Lutz, former Vice Chairman of General Motors, wrote an op-ed in which he predicted that electric, autonomous on demand mobility services would soon dominate the transportation sector. In fact, he predicts that the compelling value (in terms of economics and safety) would result in legislation removing the right of Americans to drive their own vehicles within 20 years.[19]

I personally do not subscribe to forecasts in which on-demand mobility will supplant personally owned vehicles within 20 years, or even within 50 years, but the prospects for this type of mobility solution gaining roots in certain markets and then growing in the near term cannot be ruled out. Local governments and planning commissions are seeking ways to address traffic congestion, to reduce the need for more parking spaces and to enhance the overall value of mobility. It is possible that these concepts could find their way into near- and long-term city plans, and it is nearly a foregone conclusion that electric and autonomous vehicle technology will be available when such plans are enacted. There is an opportune intersection occurring within the next 10 years where these vehicles will be capable and affordable, consumers will be ready and willing and the needs of these local governments will be acute enough to warrant new mobility paradigms gaining traction.

[18] Ryan Robinson, Deloitte, presentation at FUELS2017, Fuels Institute Annual Meeting, May 2017, Denver, CO
[19] www.autonews.com/article/20171105/INDUSTRY_REDESIGNED/171109944/industry-redesigned-bob-lutz

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While the overall impact on the market cannot be projected because the number, scope and market reach of these programs is unknown, the, Rocky Mountain Institute suggests that there are 26 potential early market adopters of such services with a potential market capitalization value of $120 billion.[20] Hence, there are dozens of companies investing in the development of capabilities and business opportunities for delivering a shared, autonomous and electric mobility solution, which only enhances the potential.

Advancements in Internal Combustion Engines

Most external factors that could affect the market that have been addressed thus far would serve to accelerate the pace of market transition away from traditional modes of transport. But despite the public announcements of automobile manufacturing companies of their intent to transition to electrified fleets, engineers have remained diligently at work to improve the internal combustion engine. This is not a contradictory situation, however. Electrification does not necessarily mean BEV and PHEV, as most auto company announcements include hybrids, which operate primarily on an internal combustion engine. And, if my projections for the rate of market conversion are close to reality, the need for enhanced efficiency in a 100+ year-old technology is critical because it will continue to dominate the fleet for decades to come.

In this space, automotive engineers are doing remarkable things to improve vehicle efficiency. They are using high strength steel to reduce weight, increasing the number of gears in transmissions, testing aerodynamics in advanced wind tunnels, and they are changing the engine. Many are using techniques that change intake valve timing to reduce the fuel-air mixture is

[20] https://www.rmi.org/insights/reports/peak-car-ownership-report/

ignited in the cylinder. Because this improves efficiency but reduces power and performance, automakers are pairing this approach with hybrid systems or turbo boosts, which ensures the driver receives the power necessary but reduces fuel consumption when possible.

In addition, two companies (Nissan and Mazda) have taken internal combustion engine design to a new level. Nissan has introduced an engine (VC-Turbo) that will adjust the compression ratio (CR) of the piston stroke to accommodate performance needs. When more power and torque are necessary, the CR can drop to as low as 8:1. This is not the most efficient mode, but it delivers power when needed. When more efficient operation is desired, the CR can increase to 14:1. Pairing this technology with a turbo boost ensures adequate performance throughout the drive cycle and reports indicate potential efficiency improvements of more than 20%.

Meanwhile Mazda will introduce an engine (SkyactiveX) next year that features a compression ignition gasoline system. Mimicking a diesel engine, this system compresses the fuel-air mixture almost to the point of auto-ignition and then uses a spark assist to ensure optimal timing of combustion. The spark assist protects against knock, but the compression system improves overall thermal efficiency. I have read reports suggesting efficiency gains of 20% to 40% with this engine.

Other automotive engineers are focusing on the optimization of an engine design to maximize efficiency with a high-octane fuel. Auto engineers, biofuel producers, petroleum producers, the Department of Energy's Co-Optimization of Fuels and Engines (a joint effort of 11 national

laboratories; I serve as External Advisory Board member)[21] and others have spent years evaluating the relationship between octane and engine design to determine that significant improvements in overall efficiency, performance and emissions can be obtained if internal combustion engines are designed to operate specifically on a higher octane fuel and do not need to accommodate alternative, lower-octane products. The Fuels Institute will be releasing a study in late spring evaluating the production capabilities of fuel producers to produce sufficient volumes of specific high-octane fuels and the market's ability to deliver such fuels to consumers. Preliminary results indicate there might be a trade-off between the most cost-efficient production options and the most cost-efficient distribution and retailing options. Much of the discussion to date has centered around the potential role for ethanol in such a market.

Each advancement in the efficiency of the internal combustion engine extends its life in the market and that of liquid fuels. Automakers are focused on achieving the emissions reductions and vehicle efficiency targets set forth by government and will use the technologies available to comply in the most cost-efficient manner possible. This may include electrification at some point, but it must include engine advancement as well.

Conclusion

The vehicle and fuels market is dynamic, with many stakeholders engaged in multiple initiatives designed to deliver compelling value to the consumer. Media outlets continue to rally around corporate and government announcements, new research papers and thought-leader statements that pronounce disruption to the traditional model of transportation and energy. Yet, when we

[21] https://www.energy.gov/eere/bioenergy/co-optimization-fuels-engines

look beyond the headlines and the hype, the market that is supposedly subject to disruptive and radical change won't get there in the next few decades without considerable external prodding.

The fundamentals of the market demonstrate that meaningful change will take time. Changing today's transportation system will not be like introducing a car engine to replace the horse and buggy, or the introduction of the smartphone to ultimately replace a wallet and personal computer. The major difference is this: Each example of a major, successful disruptive event delivered compelling, immediate and tangible value to consumers that improved their quality of life in some real way. What transportation paradigm shift could do that?

Currently, I do not see overwhelming evidence that the consumer is inclined to drive a significant pace of change, so it falls to external forces to influence the pace of change. In the absence of aggressive policies or market forces inspiring an acceleration in market transition, it is most likely that the internal combustion engine will remain the dominant powertrain in the U.S. vehicle fleet for the next several decades. And although BEVs will continue to gain market share, perhaps at a very fast pace, and alternative mobility solutions are likely to emerge in certain regions and markets, the fundamental structure of the market will evolve slowly.

Mr. SHIMKUS. I thank all of you for the testimony. We will now move to the question and answer portion of the hearing and I will begin by recognizing myself for the first 5 minutes. I am going to go on my own, my own route here for a minute.

Dr. Farrell, they are always afraid when I start doing this. Two things, one is obviously I am very interested in the Co-Optima study and the potential for high-octane fuel which has been elaborated by many of you here today. In your opening statement you mentioned the terminology, non-food biomass. So being from a corn state, would you, is that just stover and stalk or would part of that definition be hybrid corn or GMO corn that is planted specifically for the fuel market?

Mr. FARRELL. So the research that we have been doing on biomass-based routes to producing new fuels acknowledges that the current technology for producing ethanol from corn is well established and there are no real R&D challenges associated with that. When we start looking at cellulose to make ethanol as well I think we acknowledge that that technology is already commercial, albeit at low scale, but it also doesn't have the same resource to challenges.

Within Co-Optima we have been looking at the opportunities to look at a wide range of woody biomass, of energy crops, of stover, of waste residues to provide the feedstocks that will be able to provide high efficiency blend stocks including ethanol and other alcohols as well. So the research is really in focus where the greatest uncertainty lies.

Mr. SHIMKUS. Great, I appreciate that. Then I want to go to Mr. Eichberger and I appreciated the charts. That is why I wanted to get them up there. I think that is very helpful in just trying to figure out and there is public policy that probably bend that a little bit.

Mr. EICHBERGER. Of course.

Mr. SHIMKUS. But let's just take a short term window of 10 years, what a traditional—and we have had this discussion before, they used to be we called them gasoline stations. In 10 years we may call them what and what would they look like?

Mr. EICHBERGER. In 10 years they are going to look a lot like they look today and we call them convenience stores, going back to my previous job. We are going to see some diversification. We may see additional fuel blends. We are seeing some E15 on the market. That may increase. We may see some more electric vehicle charging stations on the market. Over the next 10 years we are not going to see a dramatic change in consumer behavior or the cars they are driving, so the market for fueling stations will evolve with the vehicle and the consumer. But we will see some diversification and new strategies coming forward to satisfy consumer demand.

Mr. SHIMKUS. And then to everyone, 10 years, different question, going into an auto dealership, what do you think we will see as we walk around either the showroom or get out into the lot?

Mr. Maples? Just a guess, This is kind of a 35,000-foot view of where we think we are going to be in 10 years.

Mr. MAPLES. Well, in 10 years, I would agree with the rest of the panelists that this is going to be primarily a combustion engine environment. So the vehicles that you are going to see are going to

be a lot more efficient, probably some level of hybridization whether that is a microhybrid which doesn't deliver motive power, or some other full hybrid, plug-in hybrids, and then of course EVs, and then I think that will be driven primarily by the mandates.

Mr. SHIMKUS. Dr. Farrell?

Mr. FARRELL. I agree with Mr. Maples. I would note that many OEMs are announcing intentions of producing far more models based on those provided powertrains. So we will see more electrified options, but I think the showrooms will look predominately the same.

Mr. SHIMKUS. Dr. Linn?

Mr. LINN. Yes, thanks. So suppose we are on the same path of fuel economy and emission standards and California is pursuing the Zero Emission Vehicle program, and other states, in that case I certainly would agree we will see a lot more options and probably more effort to broaden the market for those vehicles.

Mr. MARTIN. Yes. I would certainly expect more EVs. I think that is the most visible change. And there is some uncertainty about how much travel people will do in vehicles they own versus rides that they hire, in which case they wouldn't need to go to a dealer.

Mr. EICHBERGER. Mostly internal combustion engines, we will see a lot more battery electric vehicles. We have to keep in mind a lot of the automotive industry's announcement of electrification is going to be dominated by hybrids, so a lot more hybrids.

Mr. SHIMKUS. Great. And my time is expiring, but the other thing that drew my attention was Dr. Linn when you talked about, and this is my district, we will pay for more horsepower. We won't pay for more mileage. I am summarizing that research, but I think that correctly points to at least 33 counties in southern Illinois.

With that I will yield back my time and turn to the ranking member of the subcommittee, Mr. Tonko, for 5 minutes.

Mr. TONKO. Thank you, Mr. Chair. Thank you again to our witnesses. This morning we have covered a lot of ground. There are many federal and state policies, technology developments and global trends and other nations' mandates that will shape the future of fuels and vehicles.

So, Dr. Martin, in Mr. Eichberger's testimony he points out that because of the long time that a vehicle remains on the road, adoption of new engine technologies or fuels and increases in fleet fuel economy take decades to fully penetrate the transportation sector.

As was mentioned earlier, according to EPA's most recent greenhouse gas emission inventory, the transportation sector has now overtaken the electricity sector as the largest emitter of greenhouse gases in the U.S. and in recent years, the trend is upward for emissions in this sector. I am concerned about the implications of this for all air emissions including greenhouse gas emissions.

To make significant emissions reductions in this sector don't we need both cleaner fuels and more electric vehicles?

Mr. MARTIN. Yes. We absolutely need to make progress on both fuels and vehicles and to do so quickly. The long term that the vehicles stay on the road means it is even more important to do this up front.

Mr. TONKO. So what do you see as our best options in the cleaner fuels category?

Mr. MARTIN. In cleaner fuels there is a range of low carbon fuels out there. Of course, I think it is important to recognize electricity as a transportation fuel as a piece of that story as well as the biofuels we have been deploying which, you know, are getting significantly cleaner over time. And there is a lot more potential for biofuels. There is ample feedstocks to scale that up and to do it in ways that are cleaner and cleaner over time.

Mr. TONKO. And how much cleaner is today's average electricity generation than gasoline?

Mr. MARTIN. My colleague is just updating the analysis that we do of the mile per gallon equivalent of cars, of electric vehicle in terms of total pollution, and I think in terms of a weighted average across the country we are up to about 90 miles a gallon equivalent for EVs when you weight that based on where the vehicles are actually being charged.

Mr. TONKO. And electric vehicle sales have been increasing, but they still make up a very small portion of the vehicles on our roadways. Should we be investing more in the infrastructure to support electric vehicles, public charging areas, for example, to further reduce range anxiety and other barriers to electric vehicles?

Mr. MARTIN. It is certainly important to invest in infrastructure for electric vehicles. I think one of the things in our experience is that range anxiety is a larger factor before people buy an EV than after they buy one, especially with the range increasing. So, most people are finding that charging at home and charging at work is adequate to meet the vast majority of their needs.

Mr. TONKO. And I noticed in the executive summary of your 2016 report that you referred, "years of stagnation in the improvement of the efficiency of passenger cars. Would you agree that strong federal regulation, CAFE standards in particular, are needed to improve the efficiency performances in vehicles?

Mr. MARTIN. Yes, absolutely. I think the record is very clear and I think others alluded to that as well. Without strong standards the consumers won't see the benefits of improved efficiency and will remain vulnerable the next time oil prices go up.

Mr. TONKO. Well, the Trump administration may be moving toward weakening the combined CAFE and greenhouse gas standards that were proposed by the Obama administration in spite of a midterm review document that found there are technologies available now and some that will be ready soon that will allow them to meet the standards. I am very concerned that this will return us to the years of stagnation that we experienced before. Is that a fair assessment?

Mr. MARTIN. Yes, absolutely. That is a very real risk. And I think what we saw before was that American automakers become less competitive when they allow their fleets to stagnate and don't invest in improving efficiency and reducing oil use.

Mr. TONKO. So what are some of the most effective ways to accelerate the transition to cleaner fuels and vehicles?

Mr. MARTIN. Well, I think the standards that we have in place making sure those are strong and remain strong through 2025, the technical assessment report makes a very strong case for leaving them as they are and setting stronger standards that go further beyond 2025, and looking for ways to support electrification, ad-

vanced biofuels, and integrating these things thoughtfully together as we move forward.

Mr. TONKO. Well, in the debates about the lifecycle effects of different fuels and vehicles it is often pointed out that although electric vehicles do not emit anything directly, they may be drawing power from electricity sources that produce emissions. There is certainly a lively debate about the direct and indirect emissions associated with different biofuels, but we tend to assume all gasoline is equal in terms of its associated emissions.

Dr. Martin, is all oil the same in terms of its emissions?

Mr. MARTIN. Yes, it is a great point. There is a huge variability in different sources of oil, different extraction methods, and different refining processes in terms of the extent of emissions in the production of oil and gas. And since we use and will continue to use such a large amount of gasoline and diesel, these emissions from the oil and gas sector are quite large and there is a lot of opportunity to reduce those or opportunity for them to go up if they are not attended to carefully.

Mr. TONKO. All right. With that, Mr. Chair, I yield back.

Mr. SHIMKUS. You got full use of that 5 minutes. That was very efficient.

Mr. TONKO. I think we call it Tonko time. Thank you, Mr. Chair.

Mr. SHIMKUS. The Chair now recognizes the gentleman from Texas, Mr. Flores, for 5 minutes.

Mr. FLORES. Thank you, Mr. Chairman. I would love to have 10 minutes because this has been a fascinating discussion. I would like to thank the panel for being here.

Mr. Eichberger, let me start with you, two quick questions. One is, today most gas stations carry some combination of regular, a mid-grade, and then a premium grade. What do you think the opportunity is in terms of giving consumers choices in the future where they could dial in from E0 to E85? Is there anything technologically that would prevent that?

Mr. EICHBERGER. I have not seen any units entering in the market to do that. There is nothing technologically to prevent them from it. I think there are some logical reasons why we wouldn't want them to do that in terms of controlling the emissions profile of the fuels. Having consumers make their own gasoline at the dispenser I don't think is a great idea.

Mr. FLORES. Oh, you would have to put limits on it, of course, so that you wouldn't hurt the emissions restriction or the emissions profile that you are trying to achieve.

The next question I have for you is what are the challenges of facing the use of ethanol above E10 and can these challenges be overcome?

Mr. EICHBERGER. So there are compatibility issues. Every piece of equipment that a retailer uses to dispense fuel has to be listed as compatible with that fuel and up until about 10 years ago there were no dispensers listed for above E10. Some underground equipment is not listed. The transition is getting easier, but the challenge becomes that a lot of retailers aren't the original investors in the underground storage tank systems so they may not even know what equipment they have underground. If they can't certify what is underground they can't move forward with that higher fuel.

Dispensers are fairly easy to upgrade. You can get E25 dispensers for about the same price as an E10 dispenser. But you have to be absolutely certain that what you have underground is compatible as well.

Mr. FLORES. OK, thank you.

Dr. Farrell, in the past, policymakers have sort of talked about fuels policy and vehicles policy separately, so we have heard a lot of chatter about EVs. We have talked about the Renewable Fuel Standard even though this hearing is not about that. We have talked about vehicle mileage standards and so forth.

Tell me about what your thoughts are in terms of integrating all policies, fuel policy and vehicle policies, into one coherent comprehensive policy.

Mr. FARRELL. I think the opportunity that we are exploring within the Co-Optima program is really to understand from the technology standpoint what the options are. So that is one of the key benefits that we have been able to apply is understanding where those tradeoffs are in the way we are unconstrained by what is currently available in the marketplace. Our hope is that that will be the basis for an informed policy discussion which we are not participating in but we fully hope to inform.

Mr. FLORES. And I just, you didn't say this, but I am getting the inference or the implication that you think these policies should be combined from a policymaker's perspective.

Mr. FARRELL. I think from the consumer standpoint, if the goal is to get higher performing fuels and vehicles in the marketplace then looking at these as an integrated system is the most effective way.

Mr. FLORES. OK. Thank you very much. The next question for you is you are researching alternatives to the internal combustion engines. You are also looking at ways to improve the efficiency of the internal combustion engine. How much better, let's say, if you look 10 years in the future what would the internal combustion engine look like and what would the efficiency improvement be versus a 2018 engine?

Mr. FARRELL. Sure. If we look at the Department of Energy's goals for the internal combustion engine operating on today's fuels, by 2030——

Mr. FLORES. You could assume they don't have to operate on today's fuels. Again we are integrating all policy, but go ahead.

Mr. FARRELL. Yes. We will build upon.

Mr. FLORES. OK. I am with you.

Mr. FARRELL. So based on current fuels we are looking at 25 percent fuel economy benefit by 2030. By——

Mr. FLORES. What percent again?

Mr. FARRELL. Twenty five percent.

Mr. FLORES. OK.

Mr. FARRELL. By co-optimizing it and allowing additional benefits to be realized we can get an additional 10 percent or 35 percent versus today. So that is a significant benefit that is available.

Mr. FLORES. OK, great. And do you have a feel for what the cost differential would be in terms of cost per vehicle to get there?

Mr. FARRELL. Since we are looking at something 10 years down the road, the cost implications are difficult and the OEMs basically

have the opportunity to trade off costs with some other areas, so we don't have good cost estimate at this point.

Mr. FLORES. OK, thank you. I look forward to following the research as you move forward.

In terms of one of the biggest challenges to the adoption of electric vehicles is their high upfront cost, also the limitations of current battery technology. Tell me a little about, if you have done any research on this, in terms of moving beyond lithium, what that implies for cost. Lithium has a huge environmental impact that is negative, so tell us about where you think the EVs could go moving beyond lithium.

Mr. FARRELL. Sure. For the near term, I think everybody thinks that lithium-based batteries will be the main source of battery power for vehicles. The cost targets that the DOE has set for the 2022, 2023 timeframe can be achieved with improvements to current lithium technologies, but to get cost parity with ICEs requires varied costs that are about a factor 3 lower than they are today. That will require new battery chemistries. Some of those may still rely on lithium, but some of the more expensive materials such as cobalt, which has some strategic element constraints to it, will have to be removed in order to get those cost constraints down.

Mr. FLORES. OK. I would love to have more time, but I have run out of time. Thank you for your answers.

Mr. DUNCAN [presiding]. I thank the gentleman and the Chair will now go to Mr. Pallone for 5 minutes.

And I guess Mr. Peters would be next.

Mr. PETERS. I will assume my best New Jersey accent to fill in for Mr. Pallone. Thank you, Mr. Chairman, and thank the witnesses for being here.

I had a question for Mr. Linn. So there is a company called Achates Power in my district that received one of the largest ARPA–E grants to do an efficient opposed-piston engine. They are doing a lot of that for defense. It has implications for a larger use. It boosts fuel economy, decreases emissions and also, for the benefit of Mr. Shimkus, his residents, it increases horsepower.

I wonder what the ability or what you would expect in terms of innovations like that absent government intervention through front end research grants or through some other regulatory approach that would make sure that we do these incentives here in the United States?

Mr. LINN. All right. So there are already incentives just from consumers and what they want, right, to improve vehicles. We see that over decades, vehicles today are a lot different and a lot better than they were 30 years ago in all sorts of dimensions.

The way that the sort of policies can affect things are really in two ways, right. One is providing greater incentive to target those innovations toward improving fuel economy, reducing fuel consumption and emissions. The other is on the more basic research side to address the fact that there may be various reasons why the private actors aren't conducting as much research and innovation as they should be.

And so there are reasons to do both of those and that would encourage more innovation and then also direct it toward meeting these public social objectives.

Mr. PETERS. I am wondering too like what would be the incentive of if you expected higher prices from something like a carbon tax obviously I think people would be more incentivized to invest in these kinds of things. Do you agree with that?

Mr. LINN. Yes, certainly. We see, when gas prices change we see the way consumers make decisions about what vehicles to buy certainly changes. And so, by implication, carbon price would provide similar types of signals.

Mr. PETERS. Maybe ask Mr. Maples what sort of assumptions you made about the price of fuel as you have calculated the deployment of electric vehicles what assumptions you made about future costs of fuel?

You have to turn your microphone on. Want to turn your microphone on again, please?

Mr. MAPLES. Oh, sorry. In our Reference case, I think we have fuel prices going up to $3.47 a gallon by 2050. Again, EVs do get a benefit on the fuel side. The problem with the CAFE standards, or not the problem, but the issue with the CAFE standards and how that affects EV sales, you have an incumbent technology that is improving by, say, 30 percent in which, in effect, means a reduction in fuel cost of 30 percent. So that payback differential when comparing a gasoline vehicle to an EV, for example, is getting smaller.

Mr. PETERS. Right.

Mr. MAPLES. So it is making it more difficult for the EV to compete against the gasoline vehicle over that projection. So while there are fuel savings that are available for EVs, it is really the incremental cost of the vehicles that matter.

Mr. PETERS. California's Air Resources Board has simply set a level of cars that have to be on the road, electric cars that have to be on the road in the State by a certain time. That is essentially letting the car manufacturers decide how they are going to get to that point, but it has obviously created a lot of deals on hybrids and EVs that have attracted customers.

You didn't make any assumptions in your analysis about the government doing anything like that nationwide, correct?

Mr. MAPLES. That is correct. So we only have the eight States that have currently or, excuse me, the nine States plus California have currently adopted. We do allow credit trading among those States, so there is an optimization, if you will, to achieve that standard.

Mr. PETERS. Right. And that would be much more efficient for California too if we were able to expand that beyond, and I certainly think if we could get the rest of the country on board we would be willing to talk about that.

The other thing is, I wonder if you have made any assumptions about what foreign automakers are going to do in this space. We have heard the Chinese announce that they want to do, I think it was 20 percent of all car sales to be, or 20 percent of all cars to be electric. Did you consider that and would that kind of action by other countries and our competitors affect your analysis in terms of the rate of deployment?

Mr. MAPLES. So we don't specifically address that in the AEO, but we do have a feedback, a function in the model that as you

build more of these vehicles there are economies of scale that occur. So we get pretty significant reductions in battery costs and improvements in our performance of batteries for those vehicles over the projection, so they are getting far more cost effective than they are today.

Mr. PETERS. Right. And I would just finally conclude by saying to Mr. Shimkus whose move is that if you drive a Tesla it is American made, it goes pretty fast. I think you would enjoy it. Thank you. I yield back.

Mr. DUNCAN. I thank the gentleman and apologize for the name mixup. I will now go to the gentleman from Michigan, Mr. Walberg.

Mr. WALBERG. Thank you, Mr. Chair, and thanks to the panel for being with us. Coming from Michigan we are pretty proud and committed to internal combustion engines. We appreciate some of the research that is going on. The University of Michigan is doing some great research on various things including autonomous. There are other options that probably assist in reducing the use of fuels including ride sharing and things like that, but at this present time the internal combustion engine is in a pretty good place and having a NASCAR track in my district I kind of like it as well.

Mr. Maples, you mentioned in your testimony that there are several technologies available to improve the fuel economy of internal combustion vehicles. For instance, you mentioned microhybrid or stop-start technology which feels really weird at times if you are not used to that. That is for sure. You project that will be included in about 20 percent of the gasoline vehicles by 2025. By some estimates, this technology can improve fuel economy by 5 percent.

Why is it that it is only being offered to a small percentage of vehicles according to your understanding?

Mr. MAPLES. So within our evaluation and projection of technology penetration we have a menu of probably 83 technologies that are available to improve the efficiency of gasoline vehicles over the projection and so the extent to which any of these technologies are successful or how competitive they are against other options that are available to manufacturers to improve efficiency.

So engine downsizing, turbocharging, some of what has been discussed here, improved valve train designs and how those designs operate within that engine can make a big difference and then there is transmissions and then lightweighting. And so we have a considerable amount of lightweighting that also occurs in the vehicle that again has an impact on the amount of efficiency improvement that is being gained across this menu of technology.

Mr. WALBERG. So because of those multiple options, options like the stop-start technology, that is the reason why it is not included in a larger percentage because we have better approaches for various vehicles than that?

Mr. MAPLES. That is correct. So it is getting employed in those vehicles that where it is most cost-effective to do the microhybrid, the integrated start-stop.

Mr. WALBERG. What are some—OK, go ahead.

Mr. MAPLES. So for others like the pickup trucks we see a lot more lightweighting in the aluminum, other high strength steel,

transmissions being employed and turbocharging downsizing, you see more penetration there.

Mr. WALBERG. And the cost factors there are justified? Turbocharging, I assume, is a more expensive approach, but you are getting performance out of it?

Mr. MAPLES. Correct.

Mr. WALBERG. OK. Are Corporate Average Fuel Economy standards enough to encourage greater fuel efficiency or are additional incentives or requirements necessary?

Mr. MAPLES. Well, yes. EIA doesn't comment on policy, so I will——

Mr. WALBERG. Any other members of the panel that could comment on that? Yes, sir?

Mr. MARTIN. I think on the previous point, the fact that the standards could be met without the full penetration of some of these cost-effective technologies like stop-start technology reflects the ability to hit higher standards. And so, I think there are certainly opportunities to go beyond what is in the CAFE standards either by setting more stringent standards or additional policies to support rollout of oil saving fuel efficiency technology sooner.

Mr. WALBERG. Thank you. I yield back, Mr. Chairman.

Mr. SHIMKUS. The gentleman yields back his time. I think the next colleague to turn to is my friend from California, Mr. McNerney, for 5 minutes.

Mr. MCNERNEY. Well, I thank the chairman for your generous yielding and I thank the ranking member. But also the panelists, I have enjoyed your discussion.

So, history has shown that the petroleum industry is very volatile over about a 10 or 12 years' time cycle. We have been at a kind of a low point for a number of years now. Mr. Maples, you can't foresee what is going to cause these shifts usually. Do you see a change in the cycle coming and what effect that would have?

Mr. MAPLES. So we do project that oil prices are going to increase in our AEO projection, but we also offer scenarios that show different potential outcomes of the Low Oil Price case and the High Oil Price case to try to bound at an upper level and a lower level what those oil prices could be.

Mr. MCNERNEY. What is your upper bound?

Mr. MAPLES. Could I get back to you to——

Mr. MCNERNEY. Sure.

Mr. MAPLES. Yes.

Mr. MCNERNEY. Absolutely.

Mr. Eichberger, your projections seem realistic based on just the size of the fleet out there and the inertia that it has, but have you looked at what fuel prices will do in terms of accelerating the fleet turnover?

Mr. EICHBERGER. Yes. Fuel prices would accelerate it. We can take a look at that trend of hybrids. In the past, when fuel prices were 3.50 interest in hybrids of people in the market to buy a car was 82 percent. When prices dropped down below 2, it dropped down to 41 percent and sales of hybrids dropped as well. So fuel prices is a signal to consumers to start shopping around for something different.

Mr. MCNERNEY. Thank you.

One of the things that I want to drill down a little bit is standards. Mr. Linn, you talked a little bit about standards. Do you think that higher CAFE standards is beneficial to the American economy and the American consumer and the auto industry or any of the three or all of the three?

Mr. LINN. So I would say based on the research I have done that so far the standards to the sort of individual consumers and to automakers themselves have been more or less a wash. There are benefits and costs and they sort of even out. That is just narrowly on the benefit and cost to the industry itself and then there are the societal benefits for reducing oil consumption, reducing emissions. Once you add in those then, benefits would seem to outweigh the costs.

Mr. MCNERNEY. Yes.

Mr. Martin, you had a little different take on that. Could you elaborate?

Mr. MARTIN. Well, I think that there is a large benefit from fuel economy standards and the consumer savings in fuel dramatically outweigh the additional cost of the vehicle over the lifetime of the vehicle. In fact, for a vehicle that is financed the costs probably outweigh, the fuel savings offset the costs basically on the day you drive off the lot. So that is what our analysis reflects, substantial benefits to consumers from fuel economy standards even under low oil prices and if oil prices go up substantially larger benefits.

Mr. MCNERNEY. Well, it seems that the auto industry is always fighting these standards and in my mind it is essentially harming itself by doing so. Would you agree with that?

Mr. MARTIN. Yes, absolutely. They may have a preference not to invest in new technology and to keep selling the technology they have, but this will leave them vulnerable to oil price changes in the future. And particularly in a moment when electrification is accelerating, getting behind the curve on technology and oil saving technology, I think, is more critical in a moment of rapid change then it might have been in decades past.

Mr. MCNERNEY. Well, you mentioned that the U.S. is leading in the EVs and car technology now. Is that partly due to the CAFE standards? Then what is going to happen if the CAFE standards go away?

Mr, MARTIN. I think in fuel efficiency technology for the fleet the CAFE standards are certainly very important. EVs have other drivers in addition to fuel economy standards, but I think the range of support for electric vehicles, whether it is support for research, support for tax incentives, or standards, without those, one would expect less investment and less progress from the U.S. industry which could put it in a less competitive position over time.

Mr. MCNERNEY. All right, thank you.

I am not going to try to be more efficient with my time. Mr. Chairman, I yield back.

Mr. SHIMKUS. The gentleman yields back his time. The chair now recognizes the gentleman from South Carolina, Mr. Duncan, for 5 minutes.

Mr. DUNCAN. Thank you, Mr. Chairman. And there is a lot of focus on an infrastructure package that the White House is working on that we will be taking up, and I think a big part of infra-

structure should be our electrical grid. That is hardening, but that is also getting ready for the EVs of the future.

So, Mr. Farrell, what are the challenges for the electric grid, thinking of a future of considerably more EVs, and does our grid have the capacity to handle it at this point and what suggestions might you have going forward?

Mr. FARRELL. I think estimates of the projections of EVs into the marketplace suggest that the impact on the grid will be manageable. The overall change in load is a small percentage of the current because of the large base in which we are building. So the challenge is not necessarily global, it would be local, especially if we adopt fast-charging technologies which are going to be required to give very rapid fills of batteries on passenger cars, or even especially on trucks and buses the local impacts could be substantial.

So most of the work that we are doing right now, in terms of key research in these, are identifying from the infrastructure standpoint what are the impacts of putting several megawatts of power into vehicles on a very rapid on-off cycle how to manage that in terms of the grid reliability.

Mr. DUNCAN. Right. Generally, looking at infrastructure in this country I have to ask how we are going to pay for it. South Carolina just had a massive gas tax increase in our State to pay for infrastructure roads and bridges needs. EVs don't pay any gas tax when they refuel and therefore they could arguably not contribute to the upkeep of the highways even those they are using those roads.

So, Mr. Maples, are we not already subsidizing EVs because they are not subject to the gas tax, and what are your thoughts on this and should EVs be charged something for maintenance and infrastructure? Should they be subject to some sort of gas tax, so to speak?

Mr. MAPLES. So currently in our analysis that is correct. We are using basically a residential electricity price for the cost of fuel for electric vehicles. So I am aware that some States have registration fees to try to cover the gasoline taxes that aren't currently being paid by electric vehicles so that could be an option, but otherwise there would have to be something implemented at either a refueling site, a public refueling site, or somehow that electricity metered differently within the home when they are recharging to capture whatever those taxes should be.

Mr. DUNCAN. Right. I can make the argument that there are not enough EVs on the road right now to have a dramatic impact but, as Mr. Peters was saying earlier, the car companies are getting prepared for this massive increase in the number of electric vehicles that we will see in this country and I think we need to prepare for their impact on the roads and bridges and they ought to pay their fair share.

Now the electrical suppliers, the companies like Duke Energy and others, are collecting taxes from the ratepayers, but I don't see how that is translating to the infrastructure needs so I think that is something that Congress needs to work on.

I want to talk more on the rise of electric vehicles and highlight the research work that International Transportation Innovation Center is doing in tandem with my alma mater, Clemson Univer-

sity, in the Greenville, South Carolina area. They are building a global market of open and closed automotive test beds for the most advanced innovations in connected, automated, and sustainable mobility.

Clemson University and ITIC collaborate on a variety of research activity with the Department of Energy, and Clemson also has a project under the DOE's Office of Energy Efficiency and Renewable Energy called Boosting Energy Efficiency of Heterogeneous Connected Automotive Vehicle Fleets. That is a big title for something, golly. That is government at its best, in my opinion, or worst maybe. They utilize their partnership to develop anticipative and collaborative traffic and vehicle control algorithms to achieve 10 percent energy savings.

Mr. Farrell, what are the challenges that you see with integrating, I guess, not only, I guess I am thinking more autonomous vehicles than I am just electric vehicles in general. But as we think holistically about EVs and driverless cars and traffic signals, recharging stations, this is a tremendous investment on somebody's part, maybe not necessarily the Federal Government and the taxpayer.

Are you all thinking, Mr. Farrell, about that and how are you all involved in that just real quickly because you have got 10 seconds.

Mr. FARRELL. So our primary role is to understand the energy implications of an expanded autonomous and connected fleet, and analyses that we have done showed that under some conditions in the worst case scenarios you could triple energy consumption or you could get a 60 percent reduction. So the key is how to integrate it in an effective way to minimize the energy impacts.

Mr. DUNCAN. And you are working with research universities along those—yes.

Mr. FARRELL. That is right.

Mr. DUNCAN. Thank you, Mr. Chairman. I yield back.

Mr. SHIMKUS. The gentleman yields back his time. The Chair now recognizes the gentleman from Georgia, Mr. Carter, for 5 minutes.

Mr. CARTER. Thank you, Mr. Chairman. Thank all of you for being here.

Gentlemen, I have the honor and privilege of representing the entire coast of Georgia, from South Carolina all the way down to the Florida State line, about 110 miles of coastline. As you can imagine, marine travel and boats are important to us. And very important, as all of you know and as anyone who owns an outboard motor knows, fuels can be very damaging to marine vehicles, to marine boats and outboard motors. It causes a lot of deterioration, a lot of wear and tear and that is something I am concerned about.

Mr. Maples, I will go to you first and just ask you, is the EIA doing anything to look at marine engines and are you factoring anything in to the future of transportation as a result of the fuels that we are having and being forced to use in marine vessels like this?

Mr. MAPLES. So we do, so we look at the freight industry marine sector and then we also look at recreational boating and we make projections of energy consumption in both, and we do track the gas-

oline and diesel consumption in recreational boating separately from that of the rest of the transportation sector.

Mr. CARTER. What is biobutanol? Tell me about that. Are you familiar with it?

Mr. MAPLES. I am not that familiar with it.

Mr. CARTER. Anyone on the panel familiar with it a little bit? As I understand it, it is an alcohol produced from renewable plant-based energy sources or advanced feedstocks such as cellulosic biomass like wood residues. And from what I understand, at a 16.1 percent volume blend it actually has positive impacts on engines and it is less corrosive.

Does anyone know, have we looked at this as a possible fuel? I am open to anyone who is willing to——

Mr. EICHBERGER. So biobutanol has been discussed for quite a while. It is sometimes labeled with the moniker of a drop-in ready fuel, so compatibility issues are not a big issue supposedly. It has had a little trouble getting some market share and there is some limitation in terms of its——

Mr. CARTER. Can you tell me why? Is it——

Mr. EICHBERGER. Quite frankly, I think it is a lobbying thing.

Mr. CARTER. A lobbying thing.

Mr. EICHBERGER. There are a lot of stakeholders looking for a piece of this pie and this is another ingredient trying to get a piece of the fuels market and there is a lot of competition for it and I think there is some regulatory hurdles maybe to be overcome. I am not——

Mr. CARTER. OK. What are the regulatory hurdles? Can we help with that? Because if it is actually as it says, if it has positive impacts on engines and is less corrosive this is what we need to be looking for. Listen, I get calls all the time in my office about marine engines and about having to use this fuel corroding these engines.

Mr. EICHBERGER. The EPA has looked at it. You can ask EPA specifically what is their criteria for considering biobutanol and blend levels and its interaction with other constituents in fuels. It is going to come from the EPA analysis of how it interacts.

Mr. CARTER. OK. But are there regulatory hurdles that have to be overcome, is there anything we can do in Congress to assist this?

Mr. EICHBERGER. I have been told there are. I do not know specifically what they are.

Mr. CARTER. OK, fair enough. Fair enough. While I have you, while I am talking to you I will skip over to the question I have for you. The marine manufacturers again have, they have raised some concerns about how the fuel blends are marketed to consumers. For instance, one of them, E15 fuel blends in some scenarios are being marketed as unleaded 88. Are you familiar with that?

Mr. EICHBERGER. I am familiar with that, yes.

Mr. CARTER. What is going on with that? Why are they being labeled like——

Mr. EICHBERGER. The retailers who are selling E15 blended fuels are seeking an opportunity to grow their sales and because E15 has an octane rating of 88 they are able to market it as 88. They do

affix the EPA-required label for which vehicles E15 is allowed to be used in according to EPA. But they are——

Mr. CARTER. Do you think that causes some confusion among the——

Mr. EICHBERGER. There is a lot of confusion with consumers on all fuels. They like to not have to think about what fuels they are buying, so when we are thinking about bringing new fuels to the market we have to really think about how we educate the consumer. There is no consistency in terms of how the retailers are selling their E15 other than affixing that EPA-required label advising consumers which vehicles they can use them in.

E15 is not approved for marine vessels and so that is specifically labeled on that fuel it is only for 2001 and newer vehicles and not these other vehicles.

Mr. CARTER. Let me ask you all. Do you all think we can make it any more confusing? Can we all get together and see if we——

Mr. EICHBERGER. We can make it more confusing, absolutely.

Mr. CARTER. Gee. Well, we are doing a pretty good job right now, I guarantee that.

Let me skip over and, Mr. Farrell, I will go to you and ask you this question. Again I represent South Georgia so, plenty of pine trees. What about cellulosic fuels? Are we doing anything with that?

Mr. FARRELL. Yes. The Department of Energy is indeed looking at advanced cellulosic routes to produce biofuels that could have advantageous energy and emissions profiles, so that is an active area of interest.

Mr. CARTER. Right. Thank you very much.

Thank you, Mr. Chairman. I will yield back.

Mr. SHIMKUS. The gentleman yields back his time. I am going to ask unanimous consent, Mr. Johnson, if you wouldn't mind, for us to go to Mr. Loebsack because he is patiently waiting and Buddy Carter went over time before you got in the door. So with that I will recognize the gentleman from Iowa who has waited patiently, for 5 minutes.

Mr. LOEBSACK. Well, thank you very much, Mr. Chairman, and thanks for holding this hearing today and for allowing me to waive on. I really do appreciate this on the subcommittee today. There is a heck of a lot that has been talked about today, very fascinating stuff.

My main concern as you might imagine being from Iowa is the RFS so I am going to talk about that for a second. But I do want just a couple of quick notes. Mr. Walberg talked about having a NASCAR track in his district. I have one in Newton, Iowa, but they also host every year the Iowa Corn Indy 300 at that NASCAR track, so I had to get that in. We also have a National Advanced Driving Simulator at the University of Iowa. They do a lot of great work on the issues related to what you folks are talking about.

And I recently had a ride inside Iowa City with a Tesla that is advanced to be autonomous. I had a few worries as we were going through town, braking in time and all the rest, but it was actually pretty fascinating. So there is a lot to look forward to, I think, in the future as far as research on these different vehicles is concerned.

As Mr. Shimkus might expect, I do want to talk about the RFS a little bit today. It is a hotly debated topic, obviously. And I know that this is not about the RFS, but as Mr. Shimkus said, per se, it is not about that today. But it is going to be important going forward, I think, when it comes to fueling our automobiles and other vehicles down the road. There are a number of changes, I think, that are being discussed with respect to the RFS right now in Congress and I think a lot of them would be very harmful to rural America to farmers.

And I do appreciate the fact that Dr. Martin mentioned it is not just ethanol we are talking about here, it is biodiesel as well and it is advanced cellulosic, so it is a variety of things that we are talking about. But the RFS really has substantially benefited, I think, the U.S. economy over the years. It has created jobs in both renewable fuels and industry and overall agricultural industry as well, led to a pay raise for American farmers, about $6,800 per American farm it has been estimated, and has directly affected folks living in rural communities. It has lowered gas prices, I think, by giving consumers choice at the pump which we all know leads to more money in the pocket of our constituents, so that is very important.

My home State of course leads the nation in biofuels production, Iowa, and I am very proud of that. It supports probably close to 50,000 jobs in Iowa alone and accounts for a sizable proportion of our economy. Biofuels, I think, are a clean, homegrown, and high-octane alternative to fossil fuels which is very important that we have an alternative to fossil fuels, I think, for national security as much as anything as well.

The EPA has estimated as biofuel production has increased since 2007, total cropland acreage has actually dropped not risen, as some say. And, additionally, the USDA reports that demand has never been higher for conservation programs as well. I think there are some myths out there that we have to be very careful when we talk about the RFS that we set people straight on this.

Americans are consuming more and more gasoline. Gasoline consumption set a new record high in 2018 of 9.35 million barrels per day with further increases expected in 2019, and yet another reminder, I think, why we have to maintain a strong RFS. I know that domestic oil production is soaring, but we all know that production won't last forever and that falling oil prices are not going to last forever as well.

I am running short on time. I could give a lot more facts and figures, but I think in the interest of time and given the fact that I am waived to this committee today, this subcommittee today, I do just want to ask Mr. Martin. With all the different statistics that we know in mind, how would you say the RFS and strong CAFE standards help to address continued increase in gasoline consumption and carbon emissions?

Mr. MARTIN. Right. So I think vehicle fuel, vehicles policy to make vehicles more efficient, fuels policy, and also to get electric vehicles going, these things work together to cut oil use and reduce all the burdens that high oil use has on the U.S., saving consumers money and reducing greenhouse gas pollution and all the other challenges associated with oil pollution. So I think the RFS of

course is supporting the development of alternative fuels, but all those pieces fit together.

Mr. LOEBSACK. Right, I appreciate that. And I do appreciate the comments about E15 that were mentioned too, because it is the case that I know some folks have concerns about that. Mr. Carter did. But the fact of the matter is that we can make sure that we label this correctly so that people do not have problems with their engines. And I know that Senator Cruz has some concerns about that as well.

But I want to continue to work forward with the President, with the Administration, with the relevant folks to make sure that we do have a strong RFS and that we do in fact continue to contribute to our rural economies. I think it is just absolutely essential and I think we can have cleaner air and I think we can reduce our dependence on fossil fuels and make sure that we have better security for our country as well so we are not fighting wars for oil down the road.

So thank you again, Mr. Chair, for having me and I appreciate it. Thanks so much.

Mr. SHIMKUS. The gentleman's time is expired. Again the chair wants to thank the gentleman from Ohio and then recognize him for 5 minutes.

Mr. JOHNSON. OK. Thank you, Mr. Chairman. I appreciate that and I was happy to yield.

Mr. Eichberger, many of us that are not from California are not big fans of the State's disproportionate role in dictating fuels and vehicle policies. Could you talk a bit about California's role in technology forcing with regards to fuels and vehicles and what it may mean for the rest of us?

Mr. EICHBERGER. Probably not to that extent. What I can articulate is of the electric vehicles that are being sold in the market, half of them are being sold to California. I think that is encouraged a lot by the Zero Emission Vehicle program they have and the other States that have the ZEV program, and it does drive some decisions by the automakers to satisfy the largest market in the union.

Mr. JOHNSON. OK, all right. Well, thank you.

Mr. Maples, the Annual Energy Outlook for 2018 has projections out to 2040 and you see the gasoline-powered internal combustion engine remaining the most popular choice over that span. Can you explain the staying power of the internal combustion engine?

Mr. MAPLES. Sure. So again I think this really comes down to, for the alternatives to the internal combustion engine the cost of those alternatives and then the availability of alternative fuels in that refueling infrastructure, in general, just a consumer acceptance.

The gasoline vehicle is going to get much better. I think we have talked about that some here today. You are going to see significant improvements in fuel economy there, significant reductions in fuel costs for consumers of those vehicles, which I think is going to make it even more difficult for some of these alternatives to compete against it.

Mr. JOHNSON. Yes. I don't rebuild cars myself, but I know that here in America ever since the automobile was first developed it

began creating an enthusiastic consumer base for old cars, rebuilding cars, automobile enthusiasts, and so I think consumer acceptance for a lot of the new technologies is a big part of this factor that is keeping the combustion engine as the mainstay. Would you agree with that?

Mr. MAPLES. I think that is correct. OEMs right now, for example, I don't think there are any propane vehicles that are available produced from an OEM, or natural gas.

Mr. JOHNSON. Right.

Mr. MAPLES. But they do sell them as convertible if a consumer wanted to go and have those converted over. So otherwise we have plug-in vehicles as an option and then flex-fuel vehicles.

Mr. JOHNSON. Sure, OK.

Also to you, Mr. Maples, to what extent is fueling infrastructure an impediment to increased market penetration of alternatives?

Mr. MAPLES. I think with any of these alternative vehicles there are hurdles and the question is how many hurdles have to be overcome in order for these options to be successful. Policy plays a role, but certainly one of the, I think, biggest hurdles is availability of refueling of those vehicles.

Mr. JOHNSON. OK, all right.

Mr. Chair, with that I yield back a whole minute and 33 seconds.

Mr. SHIMKUS. The gentleman yields back his time.

Seeing that there are no further members wishing to ask questions for this panel, I would like to thank all of our witnesses again for being here today. Before we conclude, I would like to ask for unanimous consent to submit the following documents for the record: A letter from VNG, which is a natural gas vehicle group; and this, Fueling a Clean Transportation for the Future from the Union of Concerned Scientists.* Without objection, so ordered.

[The information appears at the conclusion of the hearing.]

Mr. SHIMKUS. In pursuant to the committee rules, I remind members that they have 10 business days to submit additional questions for the record and I ask that witnesses submit their responses within 10 days if possible upon receipt of the questions.

Without objection, the committee—before I do that, I really appreciate it. I think it was a great hearing. Members were very participative and we learned a lot. So I do appreciate and, without objection, this committee is adjourned.

[Whereupon, at 11:49 a.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

*The information has been retained in committee files and can be found at: *https://docs.house.gov/meetings/if/if18/20180307/106958/hhrg-115-if18-20180307-sd090.pdf.*

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March 5, 2018

Hon. John Shimkus
Chair, House Committee on Energy and Commerce – Subcommittee on Environment

Hon. Paul Tonko
Ranking Member, Committee on Energy and Commerce – Subcommittee on Environment

Comments by VNG
Regarding the March 7 Hearing to
Examine the Examine the Future of Transportation Fuels and Vehicles

Dear Reps. Shimkus and Tonko:

VNG.co LLC is a developer of compressed natural gas (CNG) fuel dispensing infrastructure for light- and medium-duty natural gas vehicles (NGVs). We applaud the Committee for devoting time to the important topic of transportation fuels and vehicles and we recommend natural gas and renewable natural gas (RNG) should be considered as important mainstream transportation fuels and NGVs recognized as unique vehicles which can help America improve our air quality and reduce our reliance upon petroleum based fuels.

NGVs are in some ways a much more mature and established compared to electric vehicles (EVs) and hydrogen fuel cell vehicles (HFCVs). There are over 22 million NGVs on the road globally, and, while only 150,000 are in the U.S., they are playing an increasingly prominent role in transit bus and refuse truck fleets in municipalities nationwide. However, it would be a mistake to assume that NGV technology hasn't improved significantly in recent years, or that there aren't significant untapped opportunities for further advancement. We therefore urge the Committee to include NGVs in its consideration of the future of transportation fuels and vehicles.

Renewable Natural Gas – A "Waste-to-Wheels" Emissions Game-Changer

Since 2013, there has been a dramatic transformation of the lifecycle emissions profile of NGVs due to the rapid adoption of RNG in the transportation sector. RNG, also known as biogas or biomethane, captures methane produced from a variety of sources including landfills, dairy and livestock operations, and wastewater treatment plants. Once impurities are removed, this methane can be used as a perfect substitute for fossil natural gas, including distribution in the existing natural gas pipeline system and use in NGVs.

Since methane is a powerful greenhouse gas, the use of RNG can achieve massive emission reductions on a CO2-equivalent basis when used as a transportation fuel. While lifecycle emissions can vary significantly depending on the pathway for RNG production, according to the most recent values for the California Low Carbon Fuel Standard (LCFS) it can yield emission cuts of between 50% and *400%*[1] - in other words, NGVs powered by RNG can be carbon *negative*, potentially yielding even greater emissions benefits than an electric vehicle powered entirely by solar or wind energy.

These emissions aren't a theoretical possibility. In fact, RNG fueling is increasingly the norm for NGVs thanks to the federal Renewable Fuel Standard (RFS) and the California Low Carbon Fuel Standard (LCFS). These programs have emerged as powerful economic drivers for RNG use in transportation, thanks to the reclassification of RNG as a cellulosic biofuel by EPA[2] as well as CARB's ranking of it as the lowest GHG fuel on the market. [3] Today, the value of these RFS and LCFS credits has made RNG commercially competitive with fossil natural gas.[4]

This economic driver has led to the very rapid increase in the production and sale of RNG fuel to the transportation sector – particularly in California, where fuel retailers can benefit from sales of both LCFS and RFS credits and where there are the largest number of NGVs and natural gas fueling stations. According to the RNG Coalition, over 60% of NGV fueling in California and 35% nationally comes from RNG.[5] With this trajectory of RNG growth, the emissions benefits of NGVs today are already at least as powerful as EVs and likely even greater.

Future NGV Technologies Promise Best Emissions Path for ICEs

Going beyond today's NGV technology, there is enormous untapped potential for natural gas to deliver even greater environmental and fuel economy benefits in the future. As the highest-octane, cleanest hydrocarbon fuel, natural gas has very favorable physical properties for unsurpassed performance from an internal combustion engine – if automakers are sufficiently incentivized to invest in developing this fuel to its full potential.

Natural gas has 130 octane, far beyond what gasoline – even ethanol-blended gasoline – can provide. In the "Advancing Technologies for America's Transportation Future" study, the National Petroleum Council projected that this could yield fuel economy up to double that of conventional vehicles when combined with direct injection technologies that fully utilize the properties of

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[1] CALIFORNIA AIR RESOURCES BOARD, LCFS Pathway Certified Carbon Intensities. Nov. 2017. https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.
[2] "Renewable Fuel Pathways II Final Rule to Identify Additional Fuel Pathways under Renewable Fuel Standard Program Documents." ENVIRONMENTAL PROTECTION AGENCY. July 18, 2014. https://www.epa.gov/renewable-fuelstandard-program/renewable-fuel-pathways-ii-final-rule-identify-additional-fuel-0
[3] Staff Report, CALIFORNIA AIR RESOURCES BOARD, Proposed Re-Adoption of the California Low Carbon Fuel Standard (Dec. 2014), https://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15isor.pdf
[4] *The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute*, UC DAVIS INSTITUTE OF TRANSPORTATION STUDIES, June 2016. https://www.arb.ca.gov/research/apr/past/13-307.pdf
[5] Patrick Couch, *RNG in California: More Than You Think*, FLEETS AND FUELS (Apr. 20, 2016), http://www.fleetsandfuels.com/fuels/cng/2016/04/rng-in-california-more-than-you-think/. [18] *Id.* [19] Alternative Motor Fuels Act of 1988, Public Law 100-494, 102 Stat. 2441.

CNG.[6] The leading CNG conversion company, Westport Innovations, is already investigating the potential for natural gas-fueled advanced powertrains that exploit these properties for pickup trucks, with a turbocharged direct injection platform that could reduce carbon emissions by at least 30%.[7]

The potential environmental benefits of CNG aren't limited to greenhouse gases. In 2015, Cummins Westport International (CWI) introduced a heavy-duty CNG engine that was the first engine of any kind to meet the California Air Resources Board (CARB) optional low-NOx emission standard of 0.02 g/bhp-hr NOx – 90% below the 2010 EPA certification level. [38] Owing to the inherently cleaner chemistry of natural gas compared to petroleum-based fuels, similar improvements in performance for NOx emissions could likely be achieved for light-duty vehicles given sufficient automaker interest and investment. While NOx emissions are much lower for gasoline-fueled vehicles compared to diesel vehicles, they are still significant, making this a major untapped opportunity to address smog-forming emissions on our roads.

"Bridge to Hydrogen" Needed More Than Ever

Since the earliest days of HFCV development, it has been recognized that there are numerous technical synergies between the development and commercialization of NGVs and HFCVs owing to the physical similarities between methane and hydrogen. In its 2012 light-duty vehicle rulemaking, EPA wrote that "CNG investments have the potential to facilitate the introduction of hydrogen FCVs in several respects," including innovations in advanced storage materials and tube trailer designs, improved designs for compressors and fuel dispensers, and on-site production of hydrogen from natural gas feedstock. VNG helped to lay out this rationale in a white paper, "NGVs: An Essential Bridge to Hydrogen," commissioned from the consultancy Energy Futures.[8]

As a CNG infrastructure developer, VNG is particularly aware that some of the strongest synergies between these fuels are in the area of fueling station development. Both CNG and hydrogen fueling stations require the same types of equipment, including compressors, high-pressure storage tanks, and gaseous fuel dispensers. Shared standards, equipment designs, production and operational economies of scale, and technology innovations in this area could simultaneously drive down costs for both fuels. The September 2014 report "Transitioning the Transportation Sector: Exploring the Intersection of Hydrogen Fuel Cell and Natural Gas Vehicles" by the Sandia National Laboratory[9] goes further, with a concept design for a combined hydrogen and natural gas fueling station that "could improve operational expenditures and also take advantage of common supply chains."

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[6] Report, NATIONAL PETROLEUM COUNCIL, *Advancing Technology for America's Transportation* (2012), http://www.npc.org/reports/trans.html.

[7] *Methane: The Performance Fuel*, WESTPORT INNOVATIONS (October 2015) https://cleancities.energy.gov/files/u/news_events/document/document_url/128/Brad_Douville___Westport_NGVTF_.pdf [38] *Game-Changer: Next Generation Heavy Duty Natural Gas Engines Fueled By Renewable Natural Gas*, GLADSTEIN, NEANDROSS AND ASSOCIATES (May 2016), http://ngvgamechanger.com/pdfs/GameChanger_FullReport.pdf

[8] *Natural Gas: An Essential Bridge to Hydrogen Fuel Cell Vehicles*, ENERGY FUTURES (2011) http://vng.co/wpcontent/uploads/2012/05/Natural-Gas-An-Essential-Bridge-To-Hydrogen-Fuel-Cell-Vehicles.pdf

[9] *Transitioning the Transportation Sector: Exploring the Intersection of Hydrogen Fuel Cell and Natural Gas Vehicles*, SANDIA NATIONAL LABORATORY (2014), https://energy.gov/sites/prod/files/2015/02/f19/2015-01_H2NG-ReportFINAL.pdf [41] *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues*, NATIONAL RENEWABLE ENERGY LABORATORY (2013), http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/blending_h2_nat_gas_pipeline.pdf

Fuel production is another key synergy, particularly for the production of renewable hydrogen – a requirement for hydrogen fueling in California, the leading adopter of HFCVs. RNG is an ideal feedstock for renewable hydrogen production via steam methane reforming (SMR) technology, but the market for HFCVs is currently too small to drive widespread development of these resources. As discussed previously in these comments, RNG-fueled NGVs are building the market and growing demand for this ultra-low carbon renewable feedstock in the near term, ensuring sufficient supplies of RNG for renewable hydrogen production in the longer term.

The Importance of NGVs in the Current Market Context

These present and future advances in NGV technology and the ability to incorporate renewable fuels such as RNG are particularly important to consider in the context of an auto market that has also changed significantly in recent years. Low gasoline prices have encouraged U.S. consumers to gravitate towards the purchase of larger and less fuel-efficient vehicles. After the Great Recession of 2008 decimated all classes of vehicle sales as well as oil prices, light truck sales have rebounded much more strongly than passenger vehicles and are approaching all-time highs and a market share of over 60%.[4] And even if gasoline prices rise again, these large light duty vehicles will always account for a sizable part of the market due to their unique ability to meet specific consumer and business needs.

Unfortunately, EVs and HFCVs are almost exclusively an alternative for small cars, and are likely to be so for the foreseeable future. EVs face particular challenges in applications for light trucks and pickups due to the added cost and weight of the battery packs needed to move these larger vehicles, particularly those built for carrying or towing heavy loads. Indeed, there are very few electric light trucks on the market today and no pickups, and in its 2016 technical assessment EPA did not even consider the possibility of electric towing-capable vehicles within the 2025 timeframe.[10]

Pickup trucks are the best-selling vehicles in America, as well as the most important source of profits for the "Big Three" U.S. automakers. Thus, a cost-effective solution to their emissions and petroleum dependence is absolutely essential to ensuring that these companies, their hundreds of thousands of employees, and the millions of consumers and businesses that rely on pickup trucks are not unnecessarily harmed by the agencies' regulations.

Fortunately, and in contrast to electrification, NGVs are ideally suited to be a low-emission, non-petroleum alternative fuel for light trucks and pickups especially. Larger vehicle envelopes provide ample room for CNG storage tanks, and since natural gas offers far greater energy density than batteries, it is much better-suited for moving heavy vehicles. These characteristics are why natural gas has long been the clean fuel of choice for heavy-duty vehicles like transit buses and refuse trucks, and the same logic holds true for the heavier side of the light-duty vehicle spectrum.

Indeed, automakers have demonstrated that NGVs are already a viable commercial technology for pickups. All three U.S. automakers have offered either CNG-equipped or CNG-ready

[10] Draft TAR, supra note 2, at 4-40.

versions of their flagship full-size pickups, including GM's Chevy Silverado,[11] FCA's Dodge Ram,[12] and Ford's F150. In fact, in addition to being the best-selling vehicle of any model, the 2016 Ford F-150 was named Green Car Journal's "Green Car of the Year" in part due to the availability of a CNG prep package as an option.[13]

Ensuring a Portfolio of Future Transportation Fuels and Vehicles

NGVs should be on equal footing with EVs and HFCVs, considering they deliver similar or superior emissions benefits, have significant potential for further technology advancements, and are ready for deployment in high-impact market segments that EVs and HFCVs will not be able to address for years to come.

Unfortunately, current federal policies fail to meet this policy goal, across the board. For example, EPA regulations have undercut Congress's statutory incentives for NGVs and place them at a distinct disadvantage compared to EVs and HFCVs with respect to regulatory incentives. We have attached as Appendix "A" specific recommendations for correcting these regulatory shortcomings and to encourage the production of American Made NGVs.

We urge the Committee work to remedy these shortcomings, and we are eager to meet with policymakers in all parts of government to further this important discussion.

Sincerely,

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Chief Regulatory Officer
VNG.co
rcatkinson@vng.co
908-447-4201

[11] Brandon Turkus, *2015 Chevy Silverado HD gets CNG option*, AUTOBLOG (Feb. 6, 2014), http://www.autoblog.com/2014/02/06/2015-chevrolet-silverado-hd-cng-official/.
[12] Richard Truett, *Ram will expand lineup of CNG-powered trucks*, AUTOMOTIVE NEWS (Mar. 4, 2015), http://www.autonews.com/article/20150304/OEM05/150309913/ram-will-expand-lineup-of-cng-powered-trucks.
[13] *Fuel Efficiency, Alternative Fuels and Sustainability Earn Ford F-150 2016 Green Truck of the Year Award*, FORD MOTOR CO. (Nov. 19, 2015), https://media.ford.com/content/fordmedia/fna/us/en/news/2015/11/19/ford-f-150-earns2016-green-truck-of-the-year-award.html.

Appendix "A"
Regulatory Recommendations to Incentivize NGV Production

Improving natural gas vehicle (NGV) incentives can be accomplished through simple regulatory reforms. The reforms necessary to achieve this goal are straightforward and fully justified by the game-changing environmental benefits of NGV technology, including the use of renewable natural gas (RNG), the potential for high-efficiency engines, and synergies with hydrogen fuel cell vehicles. We recommend four actions:

- **Restore 0.15 Divisor:** NGV emissions calculations should return to the "0.15 divisor" effective immediately, with emissions calculated as 85% below a gasoline vehicle (as was the case before 2016). This is justified by the game-changing real-world emissions benefits of RNG, and is moreover harmonized with Congressionally-mandated incentives under the CAFE program.

  We recommend reinstating language from the MY 2011-2016 regulations under 40 C.F.R. § 600.510–12, Calculation of average fuel economy and average carbon-related exhaust emissions.

- **Remove Dual-Fuel Design Requirements:** EPA should remove the utility factor requirements for a 2:1 ratio of CNG-to-gasoline range, as well as the requirement for dual-fuel NGVs to only use gasoline when the CNG tank is empty. These unnecessary design requirements add cost and reduce the appeal of these vehicles to consumers, and analogous plug-in hybrid electric (PHEV) vehicles face no such requirements despite having far lower driving range on electricity (<40 miles) compared to the typical natural gas range of a dual-fuel NGV pickup (250+ miles).

  This could be achieved by deleting the requirements in 40 C.F.R. § 600.510–12, Calculation of average fuel economy and average carbon-related exhaust emissions, part (c)(2)(vii)(B) for fuel economy and (j)(2)(vii)(B) for emissions.

- **NGV Pickup Incentive:** EPA has recognized the unique challenges facing full-sized pickups, and natural gas could be the ideal low-emission platform for these vehicles. This could be encouraged by offering a "Natural Gas Pickup" incentive similar to current hybrid-electric and "performance-based" pickup incentives; however, for the natural gas pickup credit, minimum deployment thresholds (10% of all full-size pickups for existing credits) should be eliminated to reflect the greater market challenges faced by NGVs - since, unlike hybrids, they use an alternative fuel.

  This could be accomplished by inserting a new section (c) under 40 C.F.R. § 86.1870–12, CO2 credits for qualifying full-size pickup trucks, titled "Credits for implementation of natural gas technology." The structure of these credits would be similar to those for sections (a) and (b), but without requirements for the "required minimum percent of full size pickup trucks."

- **Recognize Retrofits:** Encouraging retrofits of older gasoline vehicles to run on CNG is slightly more complex, but offers a unique opportunity to reduce vehicle emissions throughout their useful life instead of just at the point of sale. EPA should allow certified converters to "opt in" to the program and generate credits for CNG retrofits and upfits, prorated in proportion to their remaining useful life. Retrofits could also be encouraged by providing credits for CNG "prep packages" that reduce the costs of subsequent conversion to natural gas, as part of the off-cycle credit technologies menu listed at *40 C.F.R. § 86.1869–12, CO2 credits for off-cycle CO2-reducing technologies.*

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE
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March 22, 2018

Mr. John Maples
Senior Transportation Analyst
U.S. Energy Information Administration
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Mr. Maples:

Thank you for appearing before the Subcommittee on Environment on March 7, 2018, to testify at the hearing entitled "The Future of Transportation Fuels and Vehicles."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Thursday, April 5, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to kelly.collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

John Shimkus
Chairman
Subcommittee on Environment

cc: The Honorable Paul Tonko, Ranking Member, Subcommittee on Environment

Attachment

QUESTION FROM REPRESENTATIVE BARTON

Q1, Q2, and Q4 request information that is beyond the scope of the Energy Information Administration's mission.

Q3. What types of financial incentives currently exist through the federal government and private sector, to encourage this type of innovation?

A3. The Department of Energy's Alternative Fuels Data Center provides information on vehicle types, fueling locations and federal and state laws and incentives at https://www.afdc.energy.gov/.

QUESTION FROM REPRESENTATIVE HUDSON

Mr. Maples, thank you for coming to testify before the Subcommittee today. In your testimony, you highlight the Annual Energy Outlook out to 2050. In that outlook it shows the sharp increase in alternative fuels ad unconventional vehicles. However, you also mention that a leading cause of uncertainty is the lack of refueling infrastructure available to consumers.

Q1. Can you elaborate on this point for us? How do you think this would impact more rural customers like some of those found in my district?

A1. Current regulatory requirements are a primary driver of alternative fuel vehicle sales in our projection. EIA's Annual Energy Outlook assumes that alternative fuel infrastructure buildout is in-step with the numbers of vehicles in use and as more vehicles are sold, additional infrastructure is added to meet that demand. In reality, limited infrastructure development reduces the value of an alternative fuel vehicle to consumers and can dissuade consumer interest in those vehicles. In rural areas, infrastructure development could be more limited due to the cost of infrastructure installation relative to the potential time period it would take to realize returns on those investments given the limited number of consumers refueling. Without strong financial incentives to support infrastructure development and vehicle purchase, it is not likely that significant increases in alternative fuel vehicles will occur.

Q2. I completely agree with you this infrastructure development is a critical part in creating consumer acceptance. What incentives do you think exist that could help reach consumers outside of what we think of as traditional markets for these technologies?

A2. The U.S. Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy. As such, it does not formulate or speculate about energy policy. The Department of Energy's Alternative Fuels Data Center provides information on current vehicle types, fueling locations and federal and state laws and incentives at https://www.afdc.energy.gov/.

GREG WALDEN, OREGON
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March 22, 2018

Dr. John Farrell
Laboratory Program Manager, Vehicle Technologies
National Renewable Energy Laboratory
15013 Denver West Parkway, MS-1633
Golden, CO 80401

Dear Dr. Farrell:

Thank you for appearing before the Subcommittee on Environment on March 7, 2018, to testify at the hearing entitled "The Future of Transportation Fuels and Vehicles."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Thursday, April 5, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to kelly.collins@mail.house.gov.

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Sincerely,

John Shimkus
Chairman
Subcommittee on Environment

cc: The Honorable Paul Tonko, Ranking Member, Subcommittee on Environment

Attachment

Attachment – Additional Questions for the Record

The Honorable John Shimkus

1. Dr. Farrell, in your view, what are the benefits for future spark ignition engines of high octane fuels?

   The fuel property with the greatest impact on efficiency of spark ignition (SI) engines is the octane level. Numerous studies have shown that higher-octane fuels can deliver dramatically improved engine efficiency and performance. Determining the optimal octane level requires consideration of additional factors, such as cost and emissions.

2. Compared to other octanes which NREL has studied and researched through Co-Optima efforts, how does ethanol compare?

   The Co-Optimization of Fuels and Engines (Co-Optima) initiative has conducted a detailed and comprehensive assessment of different fuel blendstocks' potential performance in high-efficiency SI engines. This characterization factored in a wide range of fuel properties that impact efficiency, including octane levels. Co-Optima researchers are exploring blendstocks that can be produced from a wide spectrum of domestic resources, including natural gas and petroleum—as well as from domestic biomass such as forestry and agricultural feedstocks.

   Representative blendstocks from five chemical families identified by researchers as demonstrating the greatest promise of delivering fuel properties that meet performance and production requirements include small alcohols, such as ethanol. For conditions relevant to smaller, advanced turbocharged engines, small alcohols such as ethanol work well, and ethanol is typically the current market's incremental octane source of choice.

The Honorable Joe Barton

1. While we work to create new, energy efficient technologies to fuel our transportation system, are we also taking steps to make current energy sources more sustainable? For example, natural gas is one of this country's most practical energy sources and a proven fuel with many opportunities that could be explored to upgrade with new technologies. With the rapid growth in energy demand, I believe that more needs to be done to explore novel developments of this major untapped natural resource.

   NREL and DOE are pursuing a full spectrum of transportation solutions to improve the efficiency, performance, affordability, and sustainability of transportation options for consumers and businesses, including electric vehicles that are charged using renewable solar and wind power sources. At the same time, researchers are working to optimize the more conventional fuel and propulsion technologies that will continue to play an important role in transportation solutions for decades to come. Vehicles powered using plentiful, affordable domestic resources—including the United States' wealth of natural gas reserves—are important components of a broad and inclusive transportation portfolio designed to improve energy efficiency, national security, and air quality.

At the same time, numerous technical and marketplace barriers must be overcome before wider adoption of natural gas vehicles can be realized. Significant research is still needed to cost-effectively achieve diesel-like efficiency in natural gas engines for medium- and heavy-duty vehicles, while meeting current and future emissions standards.

In early March 2018, to further exploration in this area, DOE announced $4 million to support three new cost-shared research projects focused on medium- and heavy-duty, on-road natural gas engines. NREL is collaborating with three other national labs on this early-stage research, focusing on innovations to push to the next level pre-chamber spark-ignition (PCSI) technology that has demonstrated efficiency improvements up to 20% in light-duty gasoline engine.

2. What steps is the Department of Energy taking to encourage natural gas-related energy research and development for biological and catalytic technologies, methods and tools to convert natural gas into fuels, chemicals and other products? Moving forward to upgrade this vital resource in our nation not only offers alternative sources of fuel but also provides opportunities for economic growth in regions of our country where methane gas is prevalent.

   DOE continues to encourage natural gas-related R&D through recent projects including one focused on biogas biocatalysis. Researchers are developing a biocatalyst (microbe) with the capability to co-utilize carbon dioxide (CO2) and methane (CH4) to produce fuels and chemicals. Through non-photosynthetic CO2 utilization in novel hosts, the research aims to enhance CH4/CO2 uptake via targeted metabolic engineering.

   Other NREL research is already addressing a critical gap in the 11- to 13-liter engine category needed to power vocational vehicles ranging from garbage trucks and transit buses to Class 8 long-haul freight trucks. Two projects have focused on certification and commercial production of natural gas engines, utilizing both compressed natural gas and liquefied natural gas. This led to Cummins Westport's development and eventual commercial production of the 11.9-liter ISX12 G engine.

3. What types of financial incentives currently exist through the federal government and private sector, to encourage this type of innovation?

   Given that NREL does not have authority in the area of federal and private financial incentives, the Department of Energy has agreed to submit an answer to this question.

4. How would such a company present these types of ideas to the federal government for consideration?

   Given that NREL does not have authority beyond that within a National Laboratory's limited purview in how a company would present ideas to the federal government, the Department of Energy has agreed to submit an answer to this question.

The Honorable Bill Flores

1. In your testimony, you discuss the wave of innovation dramatically reshaping the concept of transportation as we know it. Often, when alternative fueling stations, such as hydrogen, are first introduced to a community, the local governments are challenged in how best to permit the stations.

   a. How could the federal government facilitate the development of these fueling stations?

      As consumer adoption of fuel cell vehicles gains momentum, the federal government could consider supporting research to overcome technical challenges faced by industry in scaling up from today's ~200 kg/day stations to the >1000 kg/day high-throughput hydrogen fueling stations needed to achieve full commercial success. In addition, national infrastructure strategy could improve reliability, decrease cost, and optimize use of domestic energy sources while supporting successful deployment of advanced transportation technologies to move people and goods using light-duty passenger vehicles, heavy-duty commercial trucks, and other vocational vehicles and equipment. These efforts are aligned with DOE's H2@Scale initiative, which focuses on R&D to generate low-cost hydrogen from diverse domestic resources for multiple applications, including transportation, energy storage, and industrial uses.

   b. Could the federal government provide some sort of consistency in permitting alternative fueling infrastructure, for hydrogen or others, to facilitate the development of fueling stations?

      Permitting for any type of fueling station is currently led by local jurisdictions, which rely on a mix of ordinances and procedures. Because of this, the primary focus of federal efforts in supporting permitting are:

      - Conducting research to evaluate the safety and performance of new technologies
      - Providing access to the latest research via publications, tools, and training
      - Developing standardized tools and permits
      - Making technical experts available.

      While permitting at a federal level may encourage more steady growth and adherence to relevant codes, it could also result in a more confusing patchwork between federal and local regulations and possibly have a detrimental effect on project quality and timelines. Instead, DOE has provided local governments with a range of tools and information to assist in the permitting and development of fueling stations. In a related effort driven by the hydrogen industry, NREL is working on standardized permits that local jurisdictions can use for hydrogen stations.

      Ongoing dialogue with local jurisdictions also points to the need for technical assistance in many areas, including understanding the market and the potential barriers to success for new technology, educating local jurisdictions and first responders as new stations are established, and partnering among cities to build fueling corridors.

2. The availability of fueling infrastructure is critical to the widespread adoption of alternative fuel vehicles. In what manner is NREL examining challenges that new technologies face, such as cost and fueling infrastructure barriers?

   NREL research and development optimizes fueling infrastructure technologies to increase station reliability and decrease consumer fuel costs through improving safety, nozzle and dispenser technology, metering, material compatibility, resilience, and systems integration. NREL also provides analysis and analytic tools to support decisions on infrastructure placement and costs. Finally, NREL collaborates closely with industry partners on applied infrastructure research to ensure that the most challenging technical issues are being addressed in ways that will lead to better, more affordable fueling options for U.S. consumers as hydrogen production is scaled up. As mentioned above, these efforts are aligned with DOE's H2@Scale initiative.

   The following provide more detailed information on NREL's work that addresses infrastructure issues:

   - Transportation Big Data – Unbiased Analysis and Tools to Inform Sustainable Transportation Decisions
     https://www.nrel.gov/docs/fy16osti/66285.pdf
   - Scenarios of Early Market Fuel Cell Electric Vehicle Introductions
     https://www.nrel.gov/docs/fy13osti/56588.pdf
   - California Power-to-Gas and Power-to-Hydrogen Near-Term Business Case Evaluation
     https://www.nrel.gov/docs/fy17osti/67384.pdf
   - Performance of Existing Hydrogen Stations
     https://www.nrel.gov/docs/fy18osti/70527.pdf
   - CNG VICE Model evaluates return on investment and payback period for new infrastructure
     www.afdc.energy.gov/vice_model
   - E85 Handling and Use Guidelines
     www.afdc.energy.gov/uploads/publication/ethanol_handbook.pdf
   - Biodiesel Handling and Use Guidelines
     www.afdc.energy.gov/uploads/publication/biodiesel_handling_use_guide.pdf
   - Costs Associated with Propane Infrastructure
     www.afdc.energy.gov/uploads/publication/propane_costs.pdf
   - Costs Associated with Natural Gas Infrastructure
     www.afdc.energy.gov/uploads/publication/cng_infrastructure_costs.pdf
   - CNG and Fleets: Building your Business Case
     www.afdc.energy.gov/uploads/publication/cng_fleets_business_case.pdf.

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March 22, 2018

Dr. Joshua Linn
Senior Fellow
Resources for the Future
1616 P Street, N.W.; Suite 600
Washington, DC 20036

Dear Dr. Linn:

Thank you for appearing before the Subcommittee on Environment on March 7, 2018, to testify at the hearing entitled "The Future of Transportation Fuels and Vehicles."

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Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

John Shimkus
Chairman
Subcommittee on Environment

cc: The Honorable Paul Tonko, Ranking Member, Subcommittee on Environment

Attachment

Joshua Linn

Associate Professor, University of Maryland

Senior Fellow, Resources for the Future[1]

Questions for the Record for the Subcommittee on Environment Hearing that took place on March 7, 2018: "The Future of Transportation Fuels and Vehicles"

1. *What types of financial incentives currently exist through the federal government and private sector, to encourage this type of innovation?*

There are several forms of incentives for innovation: federal research grants, consumer subsidies, and vehicle standards. Federal research grants come from a number of programs, including the Advanced Research Projects Agency-Energy (ARPA-E). This program funds research and development of energy technologies that address energy security, environmental, or other problems. Since 2009, ARPA-E has had an annual budget of about $300 million, which has funded a range of research on power generation, storage, transportation fuels, vehicles, and other technologies. Universities and private companies have benefited (directly or indirectly) from ARPA-E funding. Only a fraction of the overall funding has been devoted to vehicle technologies, although vehicle technology researchers can apply for funding from other federal programs.

The objective of ARPA-E is to fund innovative research that ultimately benefits society, and yet is too early-stage to receive private funding. This objective is inherently challenging to meet, because evaluators of funding proposals must identify the research that has the best chance of benefiting society, and yet can't receive private funding.[2] That is, it would be wasteful to fund projects that the private sector would have funded anyway, or to fund projects that have a very low probability of success and a low societal payoff if they do succeed. Yet, there are strong economic arguments supporting federal research grant programs, because private markets may not create the societally optimal level or mix of innovation activity, given market failures in research and development.[3] Consequently, ARPA-E and other federal funding may benefit society in the long run; in fact, many technologies today, such as solar photovoltaics, would probably not be as inexpensive, efficient, and environmentally beneficial if it were not for past federal research funding.

The other innovation incentives operate via the private sector, and arise from consumer vehicle subsidies and the vehicle standards. Buyers of plug-in vehicles can receive a federal tax credit of up to $7,500, and many states offer subsidies on top of the federal tax credit. As I noted

[1] Resources for the Future (RFF) is an independent, nonprofit research institution focused on environmental, energy, and natural resource economics and policy. The opinions I expressed in these responses are my own, and represent positions of neither the University of Maryland nor RFF.

[2] See for example this article I wrote in 2012, about a similar set of challenges for loan guarantee programs: http://www.rff.org/research/publications/commentary-loan-guarantees-reconsidered.

[3] See Fischer and Newell (2008): "Environmental and Technology Policies for Climate Mitigation."

in my testimony, there are also many indirect incentives, such as offering plug-in drivers access to high occupancy vehicle (HOV) lanes. These policies encourage plug-in vehicle innovation by increasing consumer demand, which raises the profitability of selling plug-ins and attracts private investment.

Vehicle standards also provide an indirect incentive for private funding of innovation. By vehicle standards, I include the EPA greenhouse gas standards, the NHTSA fuel economy standards, and California's Zero Emission Vehicle program. Automakers can comply with the EPA and NHTSA standards by improving the average fuel economy of their gasoline-powered vehicles, or by selling more plug-in and fuel cell vehicles (the EPA program allows automakers to use a limited number of "off-cycle" emissions reductions as well). Perhaps the most obvious way that the standards incentivize plug-in and fuel cell vehicles is the fact that for each of those vehicles sold, the automaker generates compliance credits that it can sell to other companies. Or alternatively, the automaker selling those vehicles can use the credits for its own compliance, reducing the need to improve the average fuel economy of its gasoline-powered vehicles.

The federal standards further incentivize plug-in and fuel cell vehicles.[4] Specifically, the EPA includes only liquid fuel consumption when calculating a vehicle's emissions, and does not count emissions associated with electricity generation. Moreover, EPA counts each plug-in vehicle sold as more than one toward compliance, and effectively the EPA is overcrediting those vehicles. In recent research, I estimated that these provisions of the standards effectively subsidize each plug-in by $3,000 to $10,000. Note that this is not a direct subsidy that the manufacturer actually receives, but instead it represents the benefits to the manufacturer of selling an additional plug-in. Note that the dollar amounts of these various incentives cannot be added to one another to compute the total incentive for these vehicles, but the dollar amounts give a sense of the overall level of support these vehicles receive.

2. *How would such a company present these types of ideas to the federal government for consideration?*

Of the three forms of incentives described above, only federal research grants constitute direct funding by the federal government to a company. As noted above, ARPA-E funds a wide range of research besides vehicle research, although there are other sources of federal research funding that a company interested in vehicle research might receive.

The federal standards and various policies subsidizing plug-in vehicles incentivize new research ideas. The incentives may be strongest for the automakers themselves, rather than other potential innovators, because the automakers can profit directly from the innovation. As noted above, federal funding for vehicle research at other organizations, such as universities or other companies, has been limited.

[4] See Linn and McConnell "The Role of State Policies under Federal Light-Duty Greenhouse Gas Emissions Standards."

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE
2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6115
Majority (202) 225–2927
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March 22, 2018

Dr. Jeremy Martin
Senior Scientist
Union of Concerned Scientists
1825 K Street, N.W.; Suite 800
Washington, DC 20006

Dear Dr. Martin:

Thank you for appearing before the Subcommittee on Environment on March 7, 2018, to testify at the hearing entitled "The Future of Transportation Fuels and Vehicles."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Thursday, April 5, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to kelly.collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

John Shimkus
Chairman
Subcommittee on Environment

cc: The Honorable Paul Tonko, Ranking Member, Subcommittee on Environment

Attachment

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April 4, 2018

The Honorable Joe Barton
House of Representatives
Subcommittee on Environment
Committee on Energy and Commerce
2125 Rayburn House Office Building
Washington, DC 20515

RE: Additional Questions for the Record

Dear Representative Barton,

Below are responses to the questions sent in response to the March 7, 2018 hearing *The Future of Transportation Fuels and Vehicles*.

Sincerely,

[redacted]

Dr. Jeremy Martin
Union of Concerned Scientists

The Honorable Joe Barton

1. What types of financial incentives currently exist through the federal government and private sector, to encourage this type of innovation?

The Department of Energy and the National Labs provide critically important support for innovation in the area of advanced vehicles and fuels, so ensuring DOE has the resources to continue to support innovation is important. Stable administration of vehicle and fuel standards also support investment in innovative advanced fuels and vehicle technology. The federal government also offers several tax credits, including the second-generation biofuel producer credit (26 USC 40(b)(6)) and the carbon dioxide sequestration credit (45Q).

2. How would such a company present these types of ideas to the federal government for consideration?

Companies researching advanced vehicle and fuel technologies often present them for support through Department of Energy solicitations. For example, ARPA-E (Advanced Research Projects Agency - Energy) funds early stage research, including in the areas of vehicle technologies and fuels. In addition, the Department of Agriculture also offers research grants on biofuels and advanced feedstocks.

GREG WALDEN, OREGON
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COMMITTEE ON ENERGY AND COMMERCE

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March 22, 2018

Mr. John Eichberger
Executive Director
Fuels Institute
1600 Duke Street; Suite 700
Alexandria, VA 22314

Dear Mr. Eichberger:

Thank you for appearing before the Subcommittee on Environment on March 7, 2018, to testify at the hearing entitled "The Future of Transportation Fuels and Vehicles."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Thursday, April 5, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to kelly.collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

John Shimkus
Chairman
Subcommittee on Environment

cc: The Honorable Paul Tonko, Ranking Member, Subcommittee on Environment

Attachment

Fuels Institute

April 5, 2018

The Honorable John Shimkus
Chairman
Energy and Commerce Committee,
Subcommittee on Environment
2125 Rayburn House Office Building
Washington, DC 20515

The Honorable Paul Tonko
Ranking Member
Energy and Commerce Committee,
Subcommittee on Environment
2322A Rayburn House Office Building
Washington, DC 20515

Dear Chairman Shimkus and Representative Tonko,

Thank you for inviting me to testify at the March 7, 2018, hearing "The Future of Transportation Fuels and Vehicles." I hope the hearing met your expectations and provided value to you and your colleagues on the Subcommittee.

Regarding the written questions presented to me following the hearing, please find my responses on the following pages. If there are any additional questions, I would be happy to respond.

Sincerely,

[redacted]

John Eichberger
Executive Director
[redacted]

Attachment.

1600 Duke Street, Suite 700
Alexandria, VA 22314
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FuelsInstitute.org

Response of John Eichberger to Written Questions
Submitted by Members of the Subcommittee on Environment

Questions Submitted by The Honorable Joe Barton

- What types of financial incentives currently exist through the federal government and private sector, to encourage this type of innovation?
- How would such a company present these types of ideas to the federal government for consideration?

I am not personally familiar with all programs that may exist to encourage innovation in the transportation energy sector, but I know that there are several that serve that purpose. Among those with which I am familiar are the alternative fuel vehicle and infrastructure tax credits. These programs provide tax incentives to encourage the availability of alternative fuel vehicles and the availability of alternative transportation energy to consumers, including electricity, natural gas, propane and biofuels.

From my experience with the retail fueling industry, such incentives can be helpful to encourage a company that is already considering such products to make the final decision to invest – in other words, by defraying the cost of investment, a tax credit can help a retailer get off the fence and move forward with an alternative fuel. However, it is less often that such incentives influence a company to make an investment if it was not already considering doing so.

Among other initiatives with which I am familiar that encourage innovation in the transportation energy sector are those being operated by the Department of Energy's national laboratories. For example, as my fellow witness John Farrell from the National Renewable Energy Laboratory shared during the hearing, the Co-Optimization of Fuels and Engines program is conducting early stage research to determine the technical feasibility of certain fuel components to facilitate more efficient engine performance. This type of research is often not initiated by industry, but can form the scientific foundations for advancements in market-ready fuels and engines that will ultimately benefit the consumer. In addition, the Department of Energy's Energy Efficient Mobility Systems program is researching how new mobility technologies might transform the transportation sector.

These projects feature collaborative research among the national laboratories and will deliver to the market information and analysis of potential innovations that might then be developed for commercial purposes. In this way, the federal government is supporting early stage research and technical analysis and thereby encouraging innovation throughout the transportation sector.

For companies who are developing innovative solutions for fuels and vehicles, there are a variety of opportunities to showcase such ideas to the federal government. Once again, the Department of Energy operates both the Clean Cities Program and the ARPA-E program. By contacting these programs, innovative companies might find opportunities to showcase their concepts and seek support for further research and development. This is an appropriate role for the federal government – to facilitate early stage research and analysis and to provide forums through which innovation can be introduced to a broader audience.

Question Submitted by The Honorable Richard Hudson

- Could you share with us your perspective on what could cause such a shift in consumer preferences? How can the federal government then be better prepared to adapt with changing technology so it does not create an unnecessary gap between policy and technology?

To identify what factors might compel consumers to change behavior, it is helpful to look at past experience. The smart phone debuted in the United States in 2007 and, slightly more than one decade later, they are nearly ubiquitous. Why? The smart phone has delivered an immediate, compelling value to the consumer. It has enabled advanced communications and commercial transactions to occur from most any location, freeing the user from the bounds of their desk, personal computer and landline telephone. From this technology has emerged an app-enabled economy that has transformed not only telecommunications and commerce, but ushered in a new era of social interaction, facilitated on-demand mobility, and a variety of other services that were not previously possible or even contemplated. The smart phone user can experience immediate life-style benefits by availing themselves of these services.

Disruptive transformation in the transportation sector would have to deliver similar, compelling value. Simply replacing an internal combustion engine with an electric battery to move a vehicle from point A to point B is unlikely to be deemed an overwhelming compelling value by most consumers. As these vehicles become more affordable, deliver extended range and reduced recharging time, they will become a more feasible and potentially desirable substitute for legacy technology, but I do not believe they will spark a disruptive transformation in a short amount of time.

Some have argued that autonomous, electric on-demand mobility services will be disruptive to the legacy system in a very short time. This is largely predicated on the assumption that such a service could be orders of magnitude less expensive than owning and operating a personal vehicle. While this economic assumption might be accurate, I am uncertain that enough consumers would abandon their traditional method of transportation to generate a transformative change in a short amount of time. Personal vehicles provide a certain level of utility, freedom and reliability that on-demand services may not seem to provide for all consumers. Consequently, I believe that adoption of such services will begin within certain

markets and be more prevalent among certain consumer demographics, but will not be uniform or available in all markets.

As transportation/mobility options mature, what might attract consumers en masse will be options that can affirmatively answer questions such as:

- Is this option less expensive than alternatives and, if so, how much less expensive?
- How much time will this new option save me?
- Can I access this option as conveniently as I can get into my own vehicle?
- How flexible is the option and will it accommodate my hectic schedule and complex needs?
- Am I restricted from accessing certain areas if I am not using this new option?
- What are the opportunity costs/benefits from using this new option?
- How will this option enable more efficient execution of other activities in my life?

As new options begin to satisfy questions such as these, they will begin to gain market share – potentially at a rapid pace. But I am doubtful that American consumers will replace their current mode of transportation with a new option as quickly as they adopted the smart phone.

Consequently, as the market evolves and begins to incorporate new options, the federal government has time to evaluate the relationship between technology and policy and make appropriate adjustments. I believe it is incumbent upon the government to not stand in the way of technological innovation within the transportation/mobility sector, but also to ensure the safety and security of the people. This is a careful balance that requires constant attention.

The Congress and Administration should evaluate the manner in which they are authorized to engage with industry in the early stages of innovation. I believe that the only way the government can efficiently avoid gaps between policy and technology is to know about emerging technologies in the early stages, and that requires creating opportunities for government officials to engage with industry on a regular and non-threatening basis. While the eventual deployment of technology within the transportation sector is likely to take time, the development of technological options will proceed quickly. Policies are by nature static and should be routinely reviewed for relevancy and overall impact on market development. If there are barriers which prevent the government from developing a better understanding of what is emerging, then these barriers should be reconsidered and opportunities opened.

As technologies become "road-ready," at that point government policies balancing innovation with safety and security of the people come into play. Each innovation is different and one-size-fits-all policies are not uniformly applicable. It is important that policies be crafted to ensure clarity of purpose but incorporate sufficient flexibility to ensure the government does not become a roadblock to consumer-benefiting technologies.

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